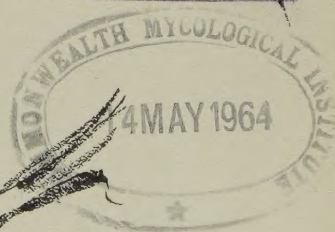
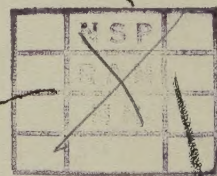
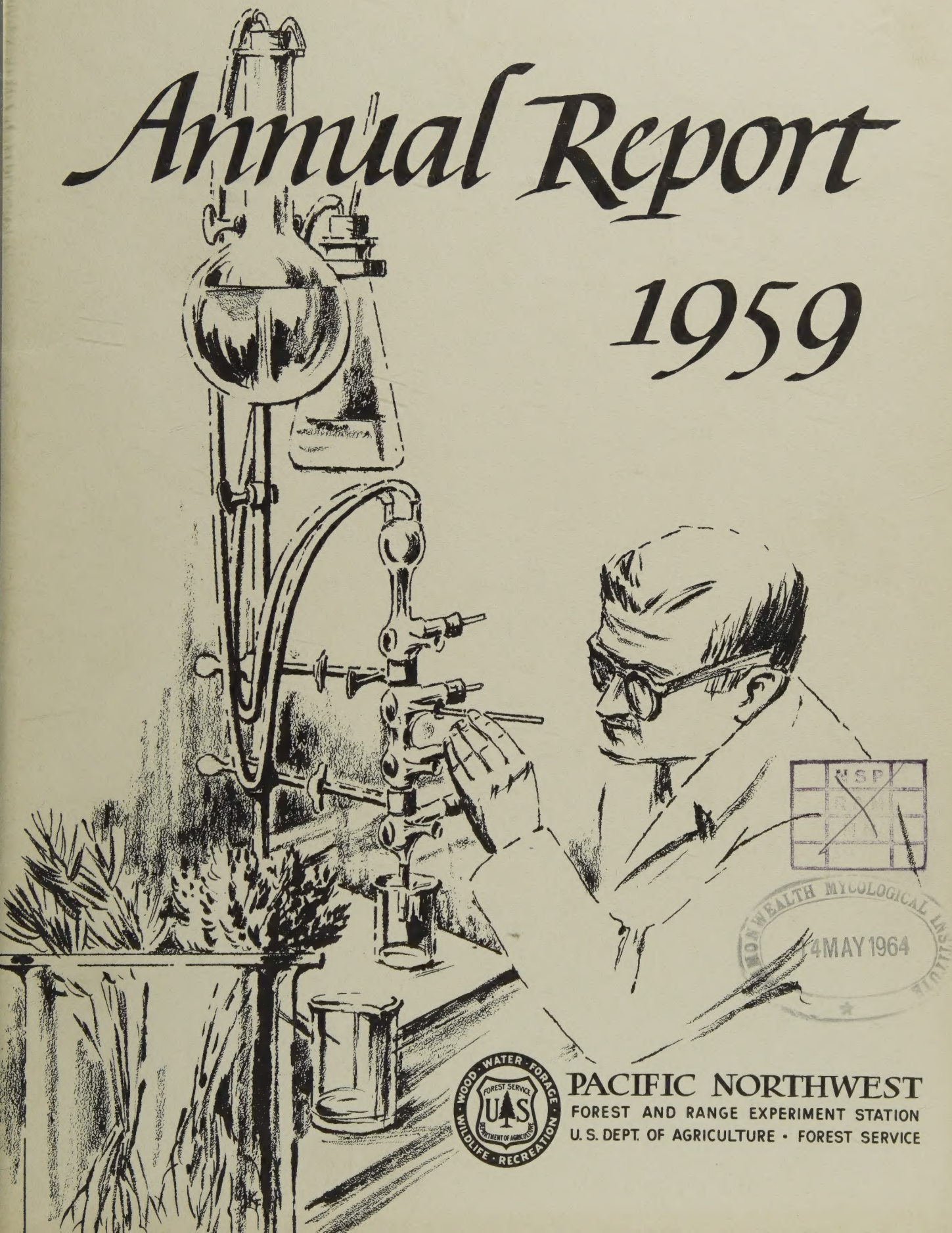


Annual Report

1959



PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
U.S. DEPT. OF AGRICULTURE • FOREST SERVICE

February 1960

PACIFIC NORTHWEST

FOREST AND RANGE

EXPERIMENT STATION

Portland, Oregon

R. W. Cowlin,

Director

COVER: Forestry researcher sterilizing surfaces of tree root tips--a step in isolating mycorrhizal fungi for study. In many areas, these fungi are necessary for survival and growth of tree seedlings.

ANNUAL REPORT

1959

Contents

RESEARCH AND MULTIPLE USE OF FOREST LANDS	iii
FOREST MANAGEMENT RESEARCH	1
Forest Tree Improvement	3
Regeneration	4
Brush Development and Control	8
Thinning and Release	11
Growth and Yield	16
Plans for 1960	18
FOREST UTILIZATION RESEARCH	19
Lumber and Plywood	19
Log and Tree Grades	21
Laminating	23
Building Construction	23
Pulp and Paper	24
Packaging	25
Plans for 1960	25
RANGE, WILDLIFE HABITAT, AND RECREATION RESEARCH .	27
Range Condition and Trend	28
Management of Big-Game Ranges	32
Ecology and Physiology of Range Plants	36
New Coding System for Range Plants	40
Range Measurement Techniques	40
Plans for 1960	41

WATERSHED MANAGEMENT RESEARCH	42
Erosion	42
Forest Cover and Streamflow	47
Plans for 1960	50
FOREST DISEASE RESEARCH	51
Decay in True Firs in Upper-Slope Types	51
Dwarfmistletoe on Ponderosa Pine	53
Root Diseases	54
Drought Injury	54
Antibiotics	55
Plans for 1960	55
FOREST INSECT RESEARCH	56
Surveys and Control	56
Research Projects	58
Plans for 1960	64
FOREST FIRE RESEARCH	65
Fire-Danger Rating	66
1959 Fire Weather in the Douglas-fir Region	68
Plans for 1960	69
FOREST ECONOMICS RESEARCH	70
Production Economics and Marketing	70
Forest Survey	75
Plans for 1960	77
AERIAL SURVEY TECHNIQUES RESEARCH	79
Forest Inventory and Management Surveys	79
Forest Insect Surveys	81
Color Films	81
Plans for 1960	82
1959 PUBLICATIONS	83
LOCATION MAP, STATION RESEARCH CENTERS AND FIELD STUDY AREAS	

Research and Multiple Use of Forest Lands

The concept of managing forest lands for multiple use is gaining impetus as demand grows for products and services of this basic natural resource. As intensity of use increases, conflicts develop and multiple use becomes a major problem in practical application for land managers and a matter of widespread public interest.

There can be little argument with the basic objective of multiple use: to obtain optimum social and economic returns from managing forest and associated lands. If it is understood that the multiple-use concept recognizes that on many forest areas one or two of the uses may be dominant and that some areas may be managed exclusively for a single paramount use, few can object to applying multiple-use management on public forest lands. Moreover, this concept can be extended in principle to private forest lands within the political and economic framework of such ownership. Nevertheless, controversies have developed regarding this basic concept and some people have rejected it in principle. In practice, multiple use has created complex problems even when the concept and its basic objective have been accepted.

PRINCIPLES OF MULTIPLE USE

Problems which have arisen from application of multiple use can be traced largely to lack of understanding of the principles involved or to poverty of scientific information. Establishing a common frame of reference by the following premises should help overcome lack of understanding:

1. Multiple use must be applied to relatively large geographic areas such as a national forest ranger district, although combinations of uses can often be applied acre by acre.
2. Resource and combined land-management objectives must be specifically defined.
3. Conflicts of use can be expected but can be resolved objectively if pertinent facts are available.
4. Some uses may be restricted or eliminated in favor of an overriding use.

5. The situation must be considered in a dynamic, not a static, perspective. Forest lands are interrelated communities of plants and animals constantly changing through use. Plans of management must be prepared with full recognition that use of one resource may affect all other resources on the area, and they must provide for change to meet changing conditions.

It seems reasonable that a common starting point for the application of multiple use could be accepted by all people. A big task, then, is to fill the gaps in the knowledge land managers need in applying multiple use and to train them in using this information skillfully and objectively on lands for which they are responsible. Although public education is needed to create a basic understanding of multiple use, a more important immediate need is to direct research programs toward providing the necessary information on forest soils, flora, fauna, and water. This should be accompanied by development of procedures for appraisal of intangible values. Obviously, a greatly expanded and accelerated program in all fields of forest research is indicated.

RESOURCES FOR MULTIPLE USE

The Pacific Northwest has a great variety of forest resources and a great potential for producing forest benefits through effective application of multiple use. This opportunity results largely from the extreme variation in climate and geography. Consider briefly the forest resources of this region.

The Pacific Northwest contains more than a third of the sawtimber volume in the Nation. Most of the water in the Columbia River system rises in its forests and mountains. Its natural scenery is superb and becoming world famous, and each year millions of people use its forests, mountains, shores, and waters for hunting, fishing, and other outdoor recreation. This recreation use will increase greatly with the population growth of the Nation, particularly on the Pacific slope. Also, important regional livestock and mining industries are based upon forest forage and minerals. It is estimated that timber, forage, and recreation values produced annually in the Pacific Northwest amount to at least \$2 billion. If it were possible to assign a dollar value to industrial, farm, and domestic water consumed and to electrical energy developed from the forested watersheds, a large sum would be added to the \$2-billion estimate.

The two most common and most important timber types in the region are Douglas-fir and ponderosa pine. Although potential sawtimber growth under good management ranges from a low of less than 100 board feet per acre per year for the poorer pine sites to a high of more than 2,000 board feet for the best Douglas-fir sites, both types are of tremendous economic importance nationally as well as locally.

MULTIPLE-USE PROBLEMS

The great variation in environmental and resource factors of Pacific Northwest forests results in a complex of challenging problems for research, particularly as opportunities for multiple-use management of the forest resource are realized. Problems of timber production alone demand a strong, comprehensive research program in view of the character of the timber resource. Harvesting old-growth stands raises many questions concerning protection against fire, insects, diseases, and wind; harvesting methods; forest engineering; and forest products utilization. For example, we must learn how to harvest the timber crop efficiently without impairing watershed, forage, and scenic values. Many of these questions can be answered by applied research, but some--particularly in the protection field--require basic research for efficient solution. Growing new crops of timber and forest forage under intensive management on highly productive sites creates many difficult problems in regeneration, timber and forage plant growth, genetics, and control of insects, disease, and forest mammals. These also require a research program strongly oriented toward the basic approach. In addition, there is need for research on problems involving economic analysis of timber production, utilization, and marketing and on similar problems developing from production of forage and water and from recreation use involving all the resources.

The pattern of forest-land ownership in the region both complicates and helps define the problems. About half the commercial forest land and sawtimber volume is federally owned or managed, less than a tenth is in other public ownership, and the remainder is privately owned. However, less than half the private forest land is in industrial ownership and--significantly--80,000 owners with individual holdings of less than 500 acres own a third of the private commercial forest land.

The national-forest situation illustrates the need for a strong Federal forestry research program. The cut of national-forest timber in the Pacific Northwest region increased from 357 million board feet in 1939 to 1,480 million feet in 1949 and to 3,650 million feet in 1959. In 1959 this region produced 44 percent of the total harvested on all national forests. Receipts from sale of timber and other products of the region's national forests amounted to \$49 million in fiscal year 1958 and \$69 million in fiscal year 1959--equaling about 55 percent of the national total in each year.

Water as a commodity has increased greatly in value since World War II as Pacific Northwest agriculture, industry, and population have expanded. As an example of increased water demand, the pulp industry--attracted by a relatively inexpensive raw material and an apparent abundance of clean water--has grown in daily capacity during the past 15 years from 5,700 tons to more than 10,000 tons. Several more pulp plants are planned for early construction.

A more striking example of the combined use of water and wood is the fiberboard industry. Fifteen years ago there was but one board plant in the Pacific Northwest. Today there are 22 plants, with a total capacity of 280 million square feet per year (3/4-inch composite-board basis). Development of hydroelectric resources of the Columbia River system has brought new industries (such as light metals) as well as stimulated the timber products industries. Concomitant reclamation projects have expanded and intensified agriculture.

All these increasing demands on the forest resources of the Pacific Northwest have been accompanied by corresponding increases in the complexity of regional problems in multiple-use management.

RESEARCH FOR MULTIPLE USE

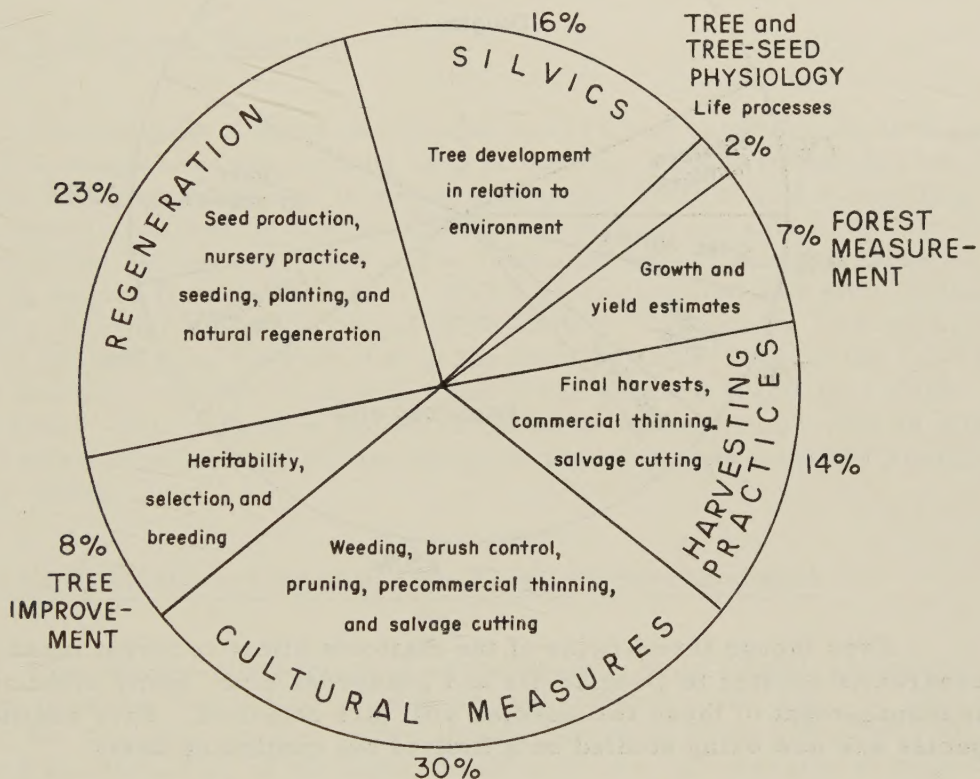
Although major effort is still in applied research fields, there has been a trend recently toward basic research as programs have expanded and matured. During this time, as previously, a high degree of coordination has existed between public and private research agencies through regional and subregional advisory committees, technical work conferences, and close professional association of scientists. A specific example illustrating both these statements is found in Station plans for constructing a small laboratory at Olympia, Wash., for study of animal damage problems in cooperation with the Fish and Wildlife Service, the Washington State Department of Natural Resources, and a number of forest industries. And high among our hopes for the future is a basic science laboratory at Corvallis, Oreg., for study of fundamental problems concerning forest insects, forest diseases, and forest tree physiology.

This report summarizes major accomplishments of the Station during 1959 and outlines plans for 1960. Although progress is encouraging, many problems in the fields of forest, range, and watershed management; wildlife habitat; and forest recreation remain to be solved. Procedures for evaluation of multiple use of forest-land resources must be established so that uses can be harmonized. Conflicts can then be resolved on the basis of the best combination of uses and services for the greatest benefit of the Nation.

R. C. Cowlin

Forest Management Research

Stripped of all window dressing, the purpose of forest management research is simply to seek out ways to increase the yield and improve the quality of timber crops. The Station's forest management staff of 18 endeavors to approach this goal through seven main avenues of inquiry, with the total effort distributed about as follows:

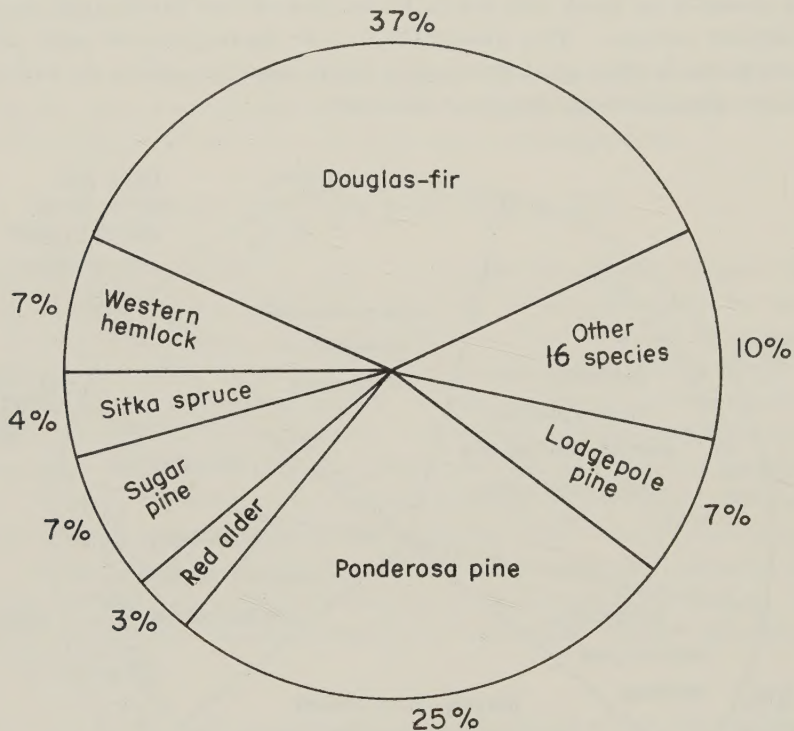


Under present staffing, only a few of the most pressing problems can be given attention. As shown by the chart, we are especially short on work in tree improvement, forest measurement, and tree physiology.

Each major species or forest type presents a distinct array of timber-growing problems needing research--how to harvest old growth; how to start a new tree crop promptly; how to train young trees through pruning, thinning, and other cultural practices; how to measure and forecast timber production; how to improve our trees through genetics; how to maintain a desirable level of growing stock in young growth during commercial thinnings; and finally,

how to correlate and combine these several operations in a logical overall plan of multiple-use management.

Altogether, Pacific Northwest forests contain more than 100 tree species. Twenty-three of these--20 conifers and 3 hardwoods--are of major commercial importance. The relative attention we give these species in our present program is shown in the following chart:



Even though three-fifths of the Station's effort in forest management research is devoted to Douglas-fir and ponderosa pine, many problems in the management of these two species still lack attention. Five additional species are now being studied on a limited but continuing basis.

The 16 species now given only cursory or intermittent attention include important trees such as western redcedar, mountain hemlock, western larch, incense-cedar, Port-Orford-cedar, Engelmann spruce, western white pine, and six species of true firs.

The kind of studies we undertake to help solve some of the high priority timber-growing problems in the Northwest are illustrated in the brief progress reports that follow.

FOREST TREE IMPROVEMENT

One of the challenging questions in the establishment of seed orchards is the possible impact of contamination from outside pollen. A 1956 study, for example, had shown that significant amounts of Douglas-fir pollen were present even at the center of one of the largest treeless areas in the Douglas-fir subregion. With more than 86 acres now devoted to Douglas-fir seed orchards, and with additional seed orchards in the planning stage, the question of contamination becomes not only interesting but important. This year, a new series of observations were made to provide better information on time and duration of pollen release and receptivity of female flowers.

Pollen Release and Elevation

Development of male and female flowers was carefully checked on 90 to 150 Douglas-fir trees along each of four elevational transects, two in western Washington and two in western Oregon. Start of pollen shedding was found to progress upward in elevation at an average rate of 71 feet per day, or about 500 feet per week. For individual trees, duration of pollen shedding varied from 7 to 15 days. For a given location, however, pollen shedding extended over a period of 20 to 30 days, and female flowers were found to be receptive over an almost identical period. Thus pollen released at any one time was practically all from trees within a 1,700-foot elevational zone. This pattern of pollen shedding is believed to provide an effective barrier to pollination of low-elevation trees by high-elevation sources, or vice versa.

Use of High-Elevation Clones in Low-Elevation Seed Orchards

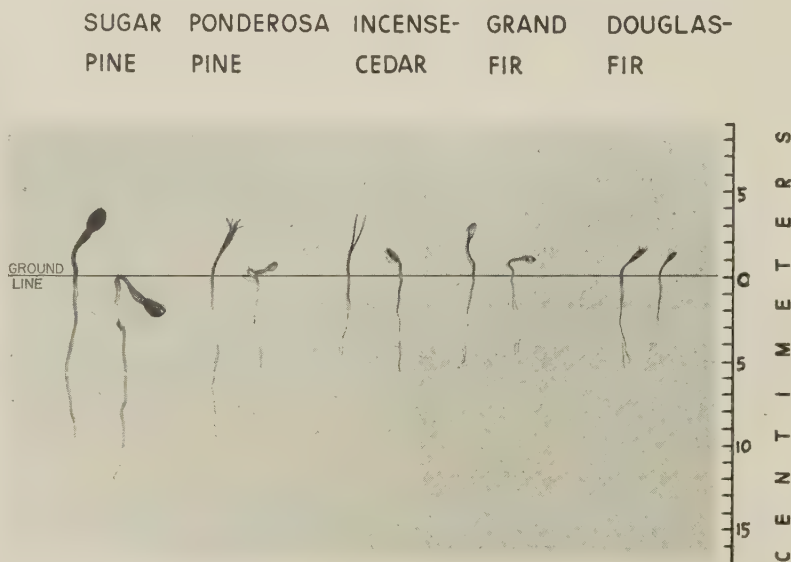
Several low-elevation seed orchards have been established specifically to produce Douglas-fir seed from high-elevation sources. In such cases, the time lag between pollen shedding of local trees adjacent to the orchard and flowering of the high-elevation clones was expected to minimize hazards of pollen contamination. Observations on flowering of both clones and nearby native Douglas-firs were made at the Dennie Ahl seed orchard near Shelton, Wash., where clones from elevations above 2,500 feet have been grafted onto stock growing at an elevation of only 600 feet. Local trees near the orchard began shedding pollen about April 26, and release continued until May 5. After a delay of only 5 days, the high-elevation clones in the seed orchard began to shed pollen on May 1, and release continued until about May 11. Thus, although the delay in flowering is not long enough to prevent pollen contamination in the seed orchard, it may help to measurably reduce contamination.

REGENERATION

First-Year Growth of Five Conifers

Differences that may be important in the initial establishment of five Northwest trees were strikingly revealed in a southwestern Oregon study. Seedlings were grown in specially prepared seedbeds in localities having coarse-, medium-, and fine-textured soils. Sample seedlings were lifted periodically to determine comparative length and weight of tops and roots. Root growth was also observed at more frequent intervals in beds equipped with glass-sided root cellars. Detailed records of air temperature, humidity, soil moisture, and soil temperature were taken throughout the growing season.

Ponderosa pine germinated first followed closely by Douglas-fir, incense-cedar, and grand fir. Sugar pine did not germinate until several weeks later. When germinating seedlings first broke through the soil, the five species differed markedly in size and appearance (right). Sugar pine had the longest radicle; ponderosa pine's was second longest and Douglas-fir's was shortest.



For all species, root penetration was several times greater than height growth. By early September, differences in root length between species were also pronounced.

Root penetration of the largest seedlings lifted from a coarse-textured soil in late September varied from 45 centimeters for grand fir to more than 120 centimeters for ponderosa pine (opposite). Average root penetration, in contrast, was only one-third to one-fifth as great.

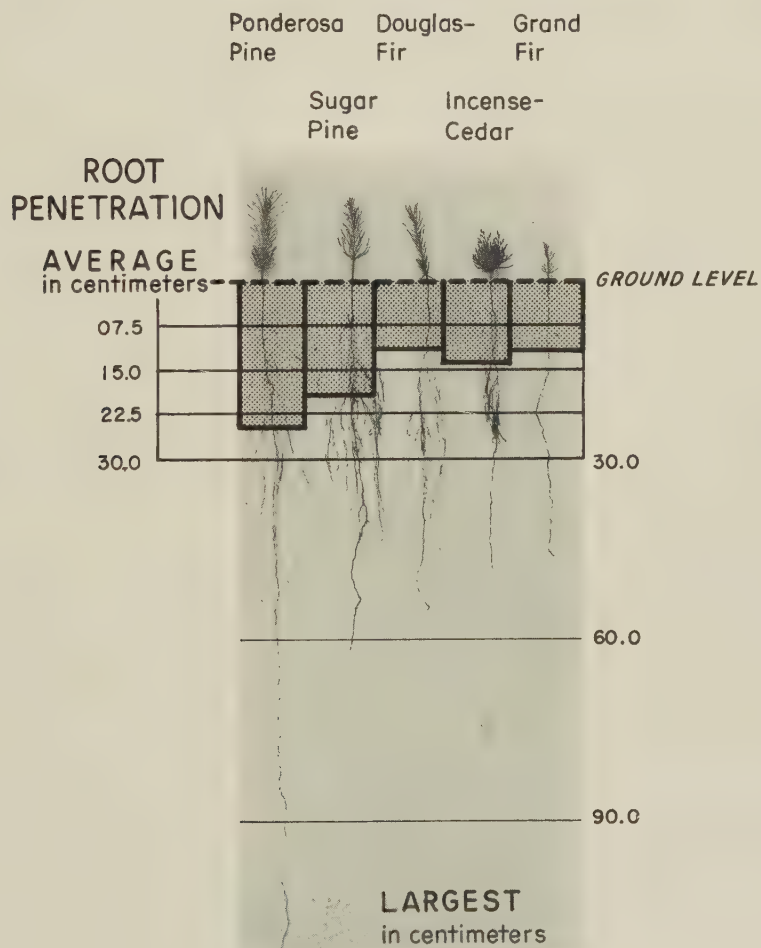
Relative ranking of the five species in depth of root penetration differed between soils, but ponderosa pine and sugar pine consistently showed the most favorable characteristics for successful establishment--high germination, good survival, rapid root penetration, and early lateral root development.

Observations in the root cellars further showed that taproot elongation for some seedlings of all species continued into early November.

Seedling Injury from High Surface Temperature

Laboratory studies of environmental conditions associated with heat injury to Douglas-fir seedlings have revealed a basic weakness in the use of surface-temperature data. In some cases, seedlings survived surface temperatures as high as 165° F.; in other tests with different surface conditions, mortality occurred at only 125° F. Thus, no single degree of surface temperature correlates directly with heat injury.

Seedlings are killed at substantially lower surface temperatures in dry organic seedbeds than in dry mineral-soil seedbeds. Computations, however, indicate that seedlings die in the two materials at about the same caloric values at the seedbed surface.



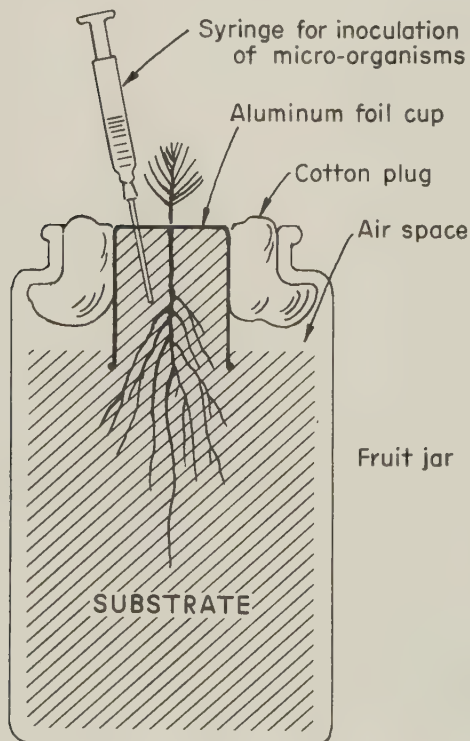
Under radiant heating, organic seedbeds provide substantially more calories for transfer to the seedling than do mineral soils with the same surface temperature. Past studies gave conflicting results because they failed to provide a measure of the actual amounts of heat transferred to the seedling.

Isolating a Mycorrhizal Fungus

In studying the effects of mycorrhizae on growth of tree seedlings, we needed pure cultures of Cenococcum graniforme. However, all our attempts to produce pure cultures through either treating root tips in the Slankis sterilization apparatus or grinding and plating root tips failed because of contamination from other fungi or bacteria. A parasitic fungus, thought to be Mycelium radialis atrovirens was especially troublesome. Apparently most mycorrhizae of Cenococcum graniforme contain deep-seated infections of organisms that cannot be removed by surface sterilization.

In contrast, when the sclerotia of the fungus rather than root tips were used, a high proportion of pure cultures was produced. The small seedlike sclerotia were picked from soil samples and sterilized before culturing.

Growing Tree Seedlings in Pure Culture



In another phase of the mycorrhizae-tree seedling study, we needed to grow tree seedlings with their entire root systems in a pure culture. This is usually done by enclosing the entire plant in a flask. A new method was devised, however, which allows the seedling tops to grow in the open and which eliminates some of the disadvantages of the flask method.

A fruit jar is filled to within 2 inches of the top with soil or with vermiculite containing a nutrient solution (left). Next, an aluminum-foil cup filled with the same material is inverted into the top of the jar, and the space between jar rim and cup is plugged with cotton. Finally, a small hole is punched through the top of the foil cup, the jar topped by a petri dish lid, and the whole apparatus autoclaved.

The radicle of an aseptic germinated seed is then inserted through the hole in the cup. When the seedling stem becomes erect, the hole is sealed with rubber cement and the petri dish lid is permanently removed. The root zone of the seedling may be inoculated with liquid cultures of fungi, using a hypodermic needle and syringe. This procedure should minimize airborne contamination.

Planting on Rotten Wood in Coastal Forests

Patches of ground covered with rotten wood are good planting sites within the spruce-hemlock forests of northwestern Oregon. Douglas-fir survived and grew equally well when planted on either mineral soil or rotten wood. Sitka spruce survived equally well on both media and attained a greater height when planted on rotten wood. Observations further indicate that competing brush is usually scarce on rotten wood.

Planting Douglas-fir in Dense Bracken

Neither pelletized nitrogen-phosphorus fertilizer nor mechanical treatment was successful in attempts to increase growth of Douglas-fir planted beneath dense bracken in coastal Washington. After three growing seasons, total height of the trees averaged only 8 inches. A survival rate of 85 percent indicated, however, that Douglas-fir seedlings can live for several years under this fern, even though growth is greatly retarded.

Mechanical treatment consisted of laying heavy building paper about the seedling or cutting the fern repeatedly. Where bracken was periodically cut, seedlings were more heavily damaged by rabbit clipping during the first year. By the end of the third year, however, neither total height nor survival differed between the treatments.

Lodgepole Pine Seed Dispersal

Now that large-scale harvesting of lodgepole pine is under way in south-central Oregon, information on seed dispersal is needed to help determine the size and pattern of cutting units. A preliminary study showed that seedfall varies from 150,000 per acre within the timber to 3,000 per acre at a distance of only 3 chains from timber edge. We plan to expand the study to include measurements at greater distances from seed sources and to determine the role of prevailing winds in seed dissemination.

Releasing Douglas-fir Seedlings from Ceanothus

The effect of a dense brush cover of varnishleaf ceanothus on development of Douglas-fir seedlings has been studied in southwestern Oregon since 1956. Seedling development under three types of brush control, including both chemical and mechanical treatments, is being compared with development under undisturbed ceanothus cover.



Under all types of release, tree growth has been markedly increased (left). The initial effect was mainly an increase in foliage density. In the second and third growing seasons, height growth of released seedlings was greatly accelerated.

The improved growth of released trees is attributed to both higher soil moisture and increased light. Measurements revealed that

at both the 3- to 6-inch and 18- to 21-inch depths, soil moisture was greater in treated areas than under undisturbed ceanothus.

BRUSH DEVELOPMENT AND CONTROL

Response of Vegetation to Partial Cutting

Seven years after partial cutting, a 109-year-old stand of site IV Douglas-fir still was found to have essentially the same density of ground-cover vegetation as before cutting. Two degrees of thinning were tried in the stand--9 and 27 percent of the original volume of 60,000 board feet per acre. Vine maple and common beargrass are the principal understory species.

These results suggest that partial cutting in Douglas-fir may be used judiciously in some situations without fear of accelerating brush development.

Control by Basal Sprays

Red alder.--Studies at Cascade Head Experimental Forest showed that young red alder can be readily controlled by basal sprays applied during the growing season. Excellent control was achieved on 6-year-old alder whose lower foot or two of stem was sprayed with 16 to 32 pounds acid equivalent of 2,4,5-T (or 2,4,5-T plus 2,4-D) in 100 gallons of diesel oil.

Dormant treatments gave less encouraging results. April application, with 96 percent defoliation of treated trees at the end of the second growing season, was much more effective than December or March application. In other trials in March, solutions containing the greatest amount of 2,4,5-T ester gave the best results. Application during dry weather proved significantly better than that during wet weather.

Bigleaf maple. -- This species sprouts vigorously from the stump, trunk, or root crown and sometimes poses a brush problem where damaged and defective trees or stumps are left after harvest cutting in the Douglas-fir region. In one instance, fast-growing sprouts from two stumps had monopolized an area 15 feet in diameter only 3 years after cutting (right).

Limited screening tests of four chemicals in the foothills of the Willamette Valley showed that only one-- a low-volatile ester of 2-(2, 4, 5-TP) in oil--was effective on bigleaf maple when applied as a basal spray. Three years after treatment, defoliation averaged 60 percent on trees up to 29 inches d.b.h. In contrast, basal sprays of low-volatile esters of 2, 4, 5-T, amitrol, and 2, 3, 6-TBA (trichlorobenzoic acid) were ineffective.

Stump sprouts were also effectively controlled by application of 2-(2, 4, 5-TP) ester in oil (right). And the cheaper chemical 2, 4, 5-T proved equally effective for controlling stump and root-collar sprouts.

Although bigleaf maple showed strong resistance to most chemicals, this exploratory study indicates that good control can be obtained by careful application of the proper chemical and through occasional re-treatment.



Aerial Spraying to Control Manzanita and Ceanothus

As a followup to small-plot experiments that showed low-volatile esters of 2,4-D will effectively control Howell manzanita, 100 acres near Butte Falls, Oreg., were aerially sprayed. An application of 4 pounds acid equivalent per acre killed 96 percent of the shrubs on one 60-acre block, while 2 pounds per acre killed only 74 percent on an adjacent 20-acre block. Two pounds of 2,4-D plus 1 pound of 2,4,5-T per acre killed 96 percent of the manzanita shrubs on another 20-acre block. All sprays were applied in diesel-oil-in-water emulsions at a rate of 7 gallons per acre.

In another trial in the Siskiyou Mountains, 3 pounds acid equivalent of 2,4-D per acre (again in 7 gallons of diesel oil emulsion) were applied from an airplane to a 2-year-old burn. Here more than 10,000 vigorous new seedlings of ceanothus and manzanita per acre had become established the first year after burning. A check of staked seedlings 1 year after spraying showed that 91 percent of the manzanita and 94 percent of the ceanothus seedlings were dead. An additional 8 percent of the manzanita and 2 percent of the ceanothus seedlings were severely damaged.

A Tractor for Brush Spraying



A broad-jet pump mounted on a crawler tractor (left) has proved satisfactory for spraying manzanita brush patches in central Oregon.

In May a dense 20-acre brush area was sprayed with 1-1/4 pounds acid equivalent of 2,4,5-T in 15 gallons of water per acre to release suppressed ponderosa pine seedlings. By fall most of the brush was dead. The operation was more expensive than aerial spraying, costing about \$7.50 per acre. But for small patches of brush interspersed with timber, or where scattered

overstory trees are present, this small tractor-pump combination seems well adapted to the job.

THINNING AND RELEASE

Thinnings, both commercial and noncommercial, afford challenging opportunities for boosting yields from young-growth forests in the Northwest. Continuing studies in Douglas-fir and ponderosa pine are gradually providing some of the information needed to help determine how heavily and frequently stands should be thinned and how the silvicultural effects of thinning vary with the age and site quality of the stand.

Extreme Thinning in a Douglas-fir Plantation

At age 23, a Douglas-fir plantation on site IV was given an extremely heavy thinning. Numbers of trees were reduced from about 650 to a range of only 50 to 350 per acre.

For the 6 years since thinning, diameter growth in the plantation has about equalled diameter growth in adjacent unthinned stands. In contrast, a striking reduction in height growth has taken place in the thinned stands, while height growth in unthinned stands has continued at a rate slightly above the prethinning level. After as long as 6 years, there is little evidence that the trees in the thinned stands are beginning to resume normal height growth.

The negative response of this stand to heavy thinning illustrates the possible hazards that may be involved when Douglas-fir growing stock is drastically reduced in one operation.

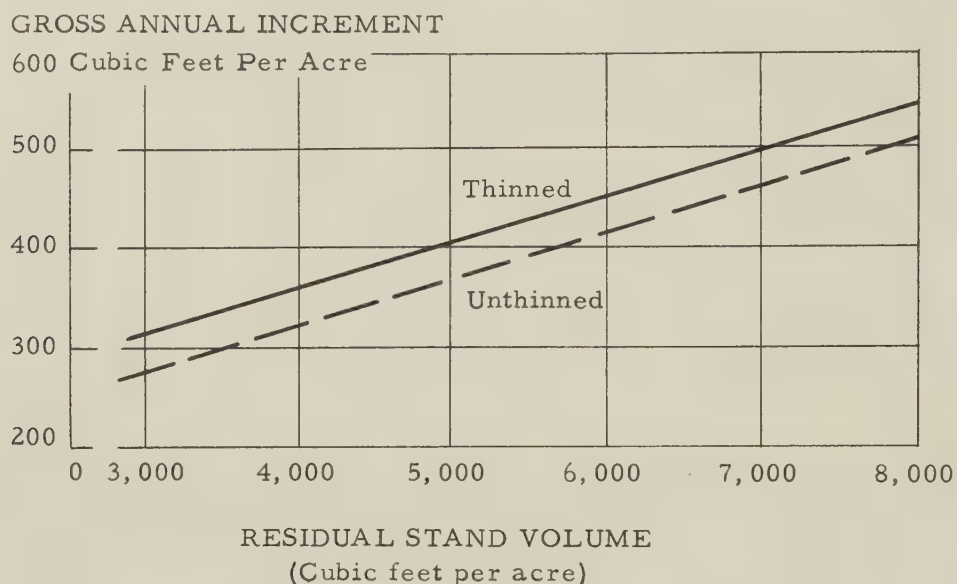
Commercial Thinning in 37-Year-Old Douglas-fir on Site III

A 6-year record of growth after thinning in site III stands at Voight Creek Experimental Forest demonstrates some of the silvicultural gains from early thinning. In this study, three thinning regimes are being compared with no thinning:

1. Heavy thinning every 9 years
2. Medium thinning every 6 years
3. Light thinning every 3 years

Over the 6-year period following treatment, gross growth per acre was about the same for all treatments, including no thinning. This indicates that growth capacity in the thinned stands has been satisfactorily redistributed to fewer stems.

A second analysis, which relates annual gross growth over the 6-year period to residual stand volume, shows that thinned stands provide a more efficient growing stock and a higher growth percent than unthinned stands (below).



Commercial Thinning in 50-Year-Old Douglas-fir on Site II

A 10-year record of growth in thinned and unthinned stands at McCleary Experimental Forest brings out some of the advantages of conservative thinnings at 5-year intervals in this age and site class. In this case, gross annual growth has been slightly higher in the unthinned stands, indicating that growth capacity has not been completely redistributed.

The salvage of mortality, however, has boosted realizable net growth in the thinned stands to 115 cubic feet per acre annually, compared with only 92 cubic feet in the unthinned stands. Expressed in terms of growth percent, the comparative figures are 1.51 and 0.94, respectively. In this example, the salvage of mortality alone has already financed road development, and the thinning operation has provided an early return on growing-stock investment without impairing net growth.

Thinning in 60-Year-Old Douglas-fir on Site IV

A 25-year record of thinned and unthinned stands near Mount Walker on the Olympic National Forest illustrates how gains from thinning are reduced as site quality decreases or as stands grow older.

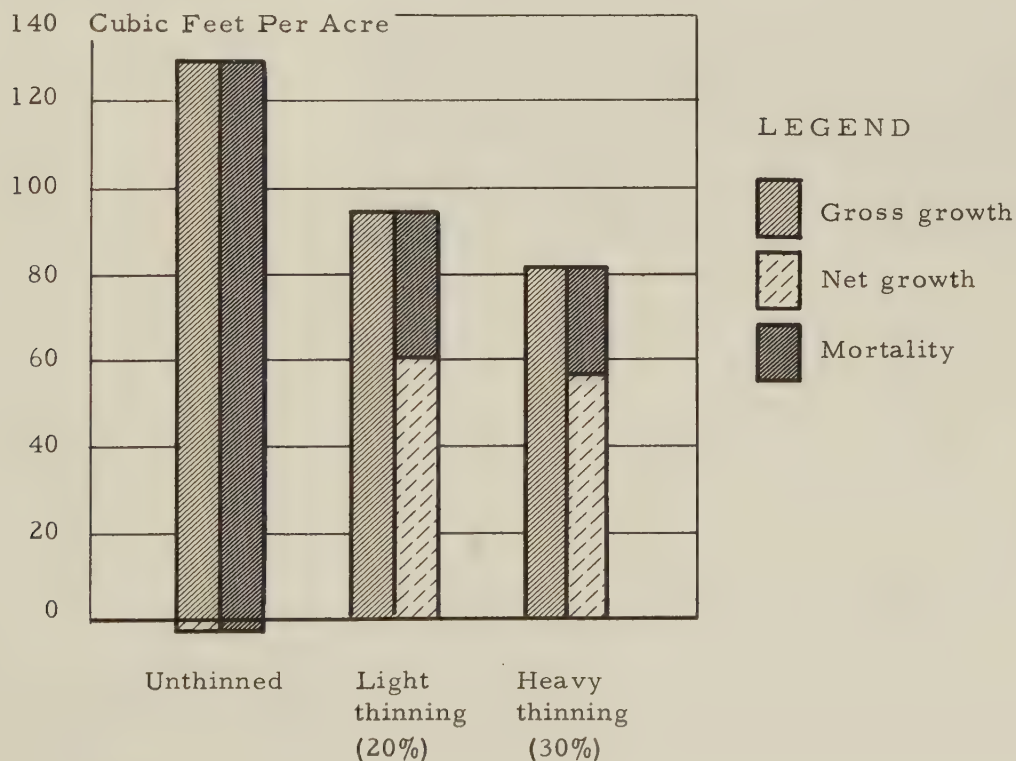
In this example, the original thinning at age 60 was mainly from below, with removals ranging from 28 to 47 percent of the cubic volume. Light rethinnings were applied at ages 75 and 84.

Up to about age 72, board-foot net growth in the thinned stands was about on a par with that in the unthinned. More recently, however, net growth in the thinned stands has dropped behind. The thinned stands likewise show no current advantage in terms of growth percent. In this case, the gains are mainly those from salvaged mortality and earlier returns. The growth comparison would probably have been more favorable, however, if the initial thinning had been lighter and if the stand had been rethinned more frequently.

Thinning in 110-Year-Old Douglas-fir on Site III

A 6-year record following thinning at Wind River Experimental Forest further indicates that older Douglas-fir trees do not have the ability to rapidly make full use of extra growing space made available through thinning. In this case, two intensities of thinning have greatly reduced gross growth and mortality (below). The pronounced gain in net growth

AVERAGE ANNUAL GROWTH AND MORTALITY



in thinned stands is mainly due to reduced mortality rather than to growth response of residual trees.

A comparison of current periodic and mean annual growth rates suggests that these stands are at or near economic and biological maturity. The record also suggests that where stands such as these need to be reserved to round out sustained yield, emphasis in management should be focused on periodic salvage of current and expected mortality.

Thinning and Bole Form of Douglas-fir

The use of standard d. b. h. measurement as an index of volume growth after thinning has been questioned because of the possibility that increased growth at breast height might merely reflect a change in bole form, or the buttressing of the lower bole on released trees.

A study of 30 released and nonreleased Douglas-fir trees at Voight Creek indicated that the form of all trees had improved slightly in the 9 years since thinning. No significant change in bole form could be attributed to release, however.

Thus, in this stand at least, d. b. h. measurements seem to provide a reasonable estimate of stem growth in both released and nonreleased trees.

For all trees, maximum radial growth occurred well up in the crown at about 90 percent of total tree height. Minimum growth occurred between breast height and 20 percent of total height. These patterns of growth are apparently normal in Douglas-fir.

Response of Suppressed Ponderosa Pine to Release

In 1934, a stand of ponderosa pine seedlings that had been suppressed for 40 years under an overstory of lodgepole pine was given full release. After 25 years, a comparison of the released and nonreleased stands should assure forest managers that ponderosa pine has the ability to respond to release and grow normally, even after long years of heavy suppression.

Unreleased trees are still living but are spindly, small, and crooked. In contrast, released trees now have the appearance of normal, healthy, young ponderosa pines.

Do Dominant Ponderosa Pines of Pole Size Respond to Release?

Six years ago we began a study at Pringle Falls Experimental Forest to help answer this question: Of 10 plots in a 65-year-old pole-sized stand, 5 were thinned leaving only dominants and a very few codominants. The five companion plots were left unthinned.



Before thinning, the stand supported 2,240 stems per acre (above). Dominants in such unthinned stands have averaged 0.52 inch of diameter growth in 6 years.

After thinning, the same stand contains only 156 trees per acre (right). Over a 6-year period, these widely spaced residual dominants have grown 0.99 inch in diameter--a rate almost double that of the dominants in unthinned stands. Height growth of dominants, however, was not influenced by thinning.



The study leaves little doubt that ponderosa pine dominants do have the ability to increase their diameter growth when competing subordinate trees are removed.

Precommercial Thinning in Red Alder

At Cascade Head Experimental Forest, a 21-year-old red alder stand was thinned in 1937; 61 percent of the trees and 45 percent of the basal area was removed. A comparison of growth in thinned and unthinned stands during the following 20 years indicates that this early thinning did not accomplish its primary objective of accelerating growth of crop trees by redistributing growth capacity to fewer stems.

Total volume at age 41 was 3,042 cubic feet in the thinned stand and 3,664 in the unthinned. The difference in total volume scarcely varied from the time of treatment. An analysis of average diameter growth of the 100 largest trees showed that the average difference in diameter growth between thinned and unthinned stands was only 0.02 inch per year. The failure of the stand to respond to this early precommercial thinning is attributed to the extremely intolerant nature of red alder. Natural thinning is highly effective because red alder dies rapidly unless it is able to maintain a position in the upper canopy.

GROWTH AND YIELD

Production in 250-Year-Old Douglas-fir

Study of a 25-acre tract of mature Douglas-fir on the Mount Hood National Forest showed continued high productivity. Net annual volume increase for a 10-year period was 25 cubic feet and 426 board feet per acre. Gross annual increment was 226 cubic feet and 1,582 board feet.

Although mortality losses were heavy, net volume was still increasing, indicating that clear cutting could, if necessary, be deferred for several years without loss of net volume. On the other hand, a high rate of gross increment indicates that intensive management of the stand, including periodic salvage, could be readily justified during the period the stand is held in reserve for final harvest.

Production in 400-Year-Old Douglas-fir

Records over the past 6 years in the Wind River Natural Area indicate that this old-growth stand is barely holding its own in terms of total volume. For all species combined, gross growth remains at a fairly high level, despite the stand's advanced age (opposite). However, this growth is largely offset by mortality, leaving net growth only a small fraction of the productive capacity of the site.

When the overall growth record is broken down by species, it becomes apparent that the more valuable but less tolerant Douglas-fir is gradually being replaced by western hemlock--the only species grouping that shows a positive net growth. Most of the mortality in "other species" is due to killing of western white pine by blister rust.

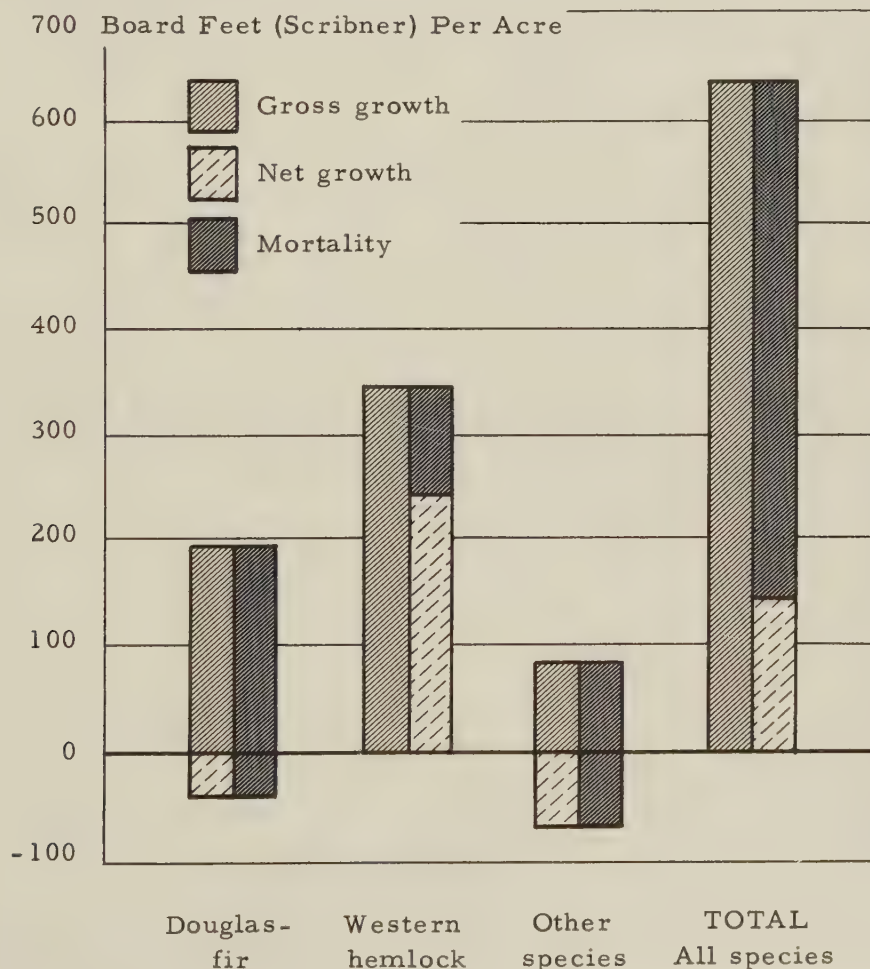
Timber lost annually in old-growth stands of this advanced age is largely of high quality and well adapted to periodic salvage.

Yield Tables for Red Alder

Red alder yield tables based on more than 400 plots in Oregon, Washington, and British Columbia have been completed and will be published during 1960. They cover a site index span of 60 to 120 feet (on a 50-year base) and stand ages from 10 to 80 years. Yields are expressed in number of trees, basal area, cubic feet, and board feet (Scribner). Culmination of mean annual increment was found to occur later than previously estimated. Where site index is 90, for example, red alder culminates in cubic feet at 40 years, and in board feet (Scribner) at 70 years.

The tables, which have been prepared through the cooperative participation of more than 28 public and private agencies, should serve as a very useful reference as the commercial value of red alder increases.

AVERAGE ANNUAL GROWTH AND MORTALITY



Potential Growth of Lodgepole Pine

A growth-predicting equation that relates gross growth in cubic feet per acre to site, age, and stand density has been developed for lodgepole pine stands on pumice soils in central Oregon. Up to about 65 years of age, the equation accounts for 84 percent of the variation. In older stands, however, no relation could be established between volume or height growth and site index. The next step in our lodgepole pine project will be the more difficult one of determining how we can concentrate total wood production on stems that will attain usable size and quality.

PLANS FOR 1960

The need to periodically revise and reorient our research program to meet the needs of critical problems of regionwide importance presents a continuing challenge in forest management research because many of these studies are necessarily of a longtime nature. Nevertheless, we plan to make two shifts in program emphasis during 1960 that we believe will enable us to give more concentrated and thorough attention to three broad fields of investigation--management of Douglas-fir, management of true fir--mountain hemlock on the upper slopes of the Cascade Range, and control of animal injury to forest trees.

During the year, a new project on the tree and tree-seed phases of animal injury will be activated at the Olympia Research Center in close cooperation with the State of Washington and the U.S. Fish and Wildlife Service. The Olympia Center will also continue to be the focal point for studies on the management of Douglas-fir, with emphasis on young growth.

Research on key species in the true fir--mountain hemlock type will, in turn, be given major attention at the Corvallis Research Center. The Corvallis Center will also continue and, if possible, expand our program in Sitka spruce and western hemlock management, with field studies mainly on the Cascade Head Experimental Forest.

Forest Utilization Research

Forest utilization research is designed to maximize product values from the forest resource without impairing timber, watershed, recreation, or range values of that resource. Thus, utilization research is related to research in forest, watershed, and range management, to forest economics, and to protection of the forest resource against insects, diseases, and fire. Whereas forest management research seeks to improve the quality and productivity of the timber resource, utilization research aims to promote complete and high-value use. Maximum productivity and utilization are important not only to forest managers, but to the forest industries and the entire economy of the Pacific Northwest.

One of our major responsibilities is liaison with the U.S. Forest Products Laboratory in Madison, Wis., where forest products research in the Forest Service is centralized. This centralized research program to improve utilization values deals with relations of timber growth to wood quality and employs all physical and chemical means to stimulate use of these properties of wood to maximum advantage. Space permits description of only a few projects to illustrate current research activity.

LUMBER AND PLYWOOD

Because major use of Pacific Northwest timber is in lumber and plywood production, special effort is made to provide basic information for these industries. In addition, we work to acquaint industry with past and current research in such fields as sawmilling, seasoning, and veneer cutting. During the year we cooperated with the Forest Products Laboratory, the two States, two trade associations, and national-forest administration in staging four sawmill clinics in Oregon and Washington. Also, Station and Laboratory personnel worked with other agencies to publicize the merits of heating Douglas-fir logs before veneer peeling. A return to this desirable practice may have been started as a result of these joint efforts.

Variation in Strength Properties of Western Softwoods

Establishing structural-design strength values for various species creates numerous problems, as exemplified by the persistent difficulty of establishing a standard value for Douglas-fir from different geographical areas. Recently, these problems have multiplied to include practically all western softwoods. There is now substantial production of western softwood plywood from species other than Douglas-fir, and increasing production of lumber from so-called secondary species. Both the plywood and

lumber industries desire to stress grade all species for marketing purposes. These trends in timber utilization are highly desirable, but they create some serious production and marketing problems for western manufacturers.

After frequent consultations with the Forest Products Laboratory during 1959, western plywood manufacturers have determined that for structural uses, plywood from hemlock and several of the western true firs should be thicker than Douglas-fir plywood to compensate for somewhat lower strength and stiffness. However, the situation is complicated by the fact that white fir (*Abies concolor*) apparently lacks the stiffness of other true firs and must be kept separate to avoid penalizing the entire group. Currently, it is not possible to identify and distinguish white fir from other true firs after it is converted to plywood or lumber. Efforts are underway to resolve the problem in one of two ways: (1) determine by extensive sampling, within the area containing timber suitable for commercial use, if white fir does have sufficient strength and stiffness to be included with other true firs and western hemlock, and (2) develop a means of separating white fir through the production plant and into the final product to assure that plywood or lumber of this species is not included with that of other western softwoods.

Increasing awareness of problems relating to strength properties of individual western woods led, in late 1959, to consideration of a comprehensive investigation of strength values as indicated by specific gravity range in standing timber. A major cooperative study, supported by industry to speed collection of field data, is currently being planned. The broad aim of this study is to determine the range in the specific gravity of each western softwood throughout Washington, Oregon, California, Idaho, and western Montana. This will be accomplished by taking increment cores from standing trees of each species on random plots. The field work will be under direction of Forest Survey personnel of the three Forest Service experiment stations involved, with coordinating responsibility at this Station.

The task of determining the average specific gravity of each tree from which an increment core is taken, as well as the work to more fully develop specific gravity-strength relationships, will be the responsibility of the Forest Products Laboratory. However, other research agencies may participate in these phases of the long-range study.

Lumber manufacturers are also faced with several related problems. For example, Los Angeles building officials are insisting that all stress-graded lumber be identified by species to insure adequate strength. Unidentified lumber will be treated as non-stress-graded stock--a severe penalty in structural use. The problems of distinguishing true firs from western hemlock or of separating individual species of true firs in production are acknowledged to be extremely difficult, but require immediate attention.

Another example is found in a recent announcement by the Federal Housing Authority. After April 1, 1960, all stress-graded lumber used in houses built under FHA inspection must be grade marked, further emphasizing the need for a method to more accurately determine the strength of individual pieces of lumber or plywood.

Degrade Studies

Seasoning lumber at the mill before shipment continues to be a major phase of lumber manufacture in the Pacific Northwest. Degrade studies to measure loss in market value of lumber resulting from avoidable seasoning and machining defects point up the opportunity to improve kiln-drying operations.

Results of such a study on Douglas-fir lumber kiln-dried at a mill in Dallas, Oreg., showed that upper grades of dimension stock suffered losses ranging from \$0.12 to \$1.44 per thousand board feet, due largely to checking and damage to knots. Lower grades of dimension, however, showed practically no loss. The more valuable finish grades suffered losses ranging from \$1 to \$12 per thousand, largely due to checking and warping. Much of the loss could be avoided by greater application of the results of seasoning research.

Studies of this kind also have application to lumber recovery studies made at sawmills where rough lumber is graded and tallied at the green chain. It is often desirable to adjust lumber recovery obtained at this stage of manufacture to the yield and value of dry, surfaced lumber.

LOG AND TREE GRADES

A continuing project of the Station and national-forest administration involves development of end-product recovery data from logs of various species, grades, and sizes. Two studies were made during the year as part of this project. One was a study to supplement data on old-growth Douglas-fir No. 2 Sawmill logs by sampling large-diameter logs from the Olympic Peninsula; the other was a study on Douglas-fir logs from the east slopes of the Cascade Range in Oregon.

A feature of the latter study was that it began with the selection of sample trees, a departure from previous procedure. Study logs were cut

from limby, open-grown trees (lower left) as well as from trees naturally pruned to the base of the crown (lower right). After the grade and volume of each log was estimated, the trees were felled and bucked. The study logs were then diagramed, graded, and scaled, and standard mill-study procedure was followed to obtain dry-lumber recovery from each log. Thus, in this study lumber recovery can be totaled for each sample tree to provide the type of information required for development of tree grades.

During the year we made a major effort to modify and adapt electronic computer procedures for analyzing the voluminous data developed from recovery studies. The modified procedure of constructing curves directly from the lumber value of individual logs simplifies computation and



presentation of findings, and--more important--permits statistical treatment of the data to measure accuracy.

Data from past recovery studies were reanalyzed under the new program. Studies on the same species were compared and combined, thereby broadening the sample. Work to combine two ponderosa pine studies and to combine four studies of east-side mixed species (Douglas-fir, western larch, and white fir) is nearly complete. We also applied this procedure to data from two west-side Douglas-fir studies, a study in Alaska, and two studies in the Intermountain region.

Preparatory to beginning a national log- and tree-grade project on Douglas-fir, we broadened recovery study procedures to provide data necessary for the development of new or modified log-grade descriptions. Lumber recovery value for each study log is now determined on a shipping tally basis. Further, each log is diagramed to show surface and end characteristics for correlation with end-product value. It is expected that this national project will be started in 1960 in the Pacific Northwest.

LAMINATING

The Station and the Forest Products Laboratory continued their cooperation with the laminating industry to develop a shorter high-strength end joint for long laminations and to develop special lumber-stress grades. Recently, the Laboratory began studying the technique of handling laminated members during erection so as to retain full structural strength in place. The Station and Laboratory are also continuing to assist the American Institute of Timber Construction in the development of standards for the design, fabrication, and erection of laminated structures.

Our program of inspecting bridges constructed with glued laminated Douglas-fir was expanded this year to include two Forest Service bridges having glued laminated stringers that were treated with pentachlorophenol in heavy oil. Both bridges, the Upper Portland Creek bridge and the Logan Creek bridge, were built in 1958. Service records on these bridges will be added to those on the Loon Lake bridge (pressure treated with waterborne salts before gluing) and to those on the Culp Creek, Smith River, and Calawah River bridges (treated with creosote after gluing), which continue to show good glue bonds.

BUILDING CONSTRUCTION

Producers, distributors, and consumers of wood products are often handicapped by lack of knowledge concerning performance of these products in use. This is especially true in the case of dwellings, where collection of performance data is complicated by the great variety of climatic conditions, construction methods, and types of occupancy, and by the fact that it is difficult to obtain data in houses after they are occupied.

Because it is important to determine the behavior of wood in use, the Forest Products Laboratory has instituted several nationwide studies. Those in which we are currently cooperating concern (1) moisture content and dimensional change in wood framing members during construction and subsequent occupancy, (2) maximum temperatures in house framing as a result of solar heat, and (3) decay hazards in residential structures.

Moisture Content and Dimensional Change in Wood Framing

To determine changes in moisture content of wood framing in residential construction and the effects of such changes on the structure, the Forest Products Laboratory began a nationwide study in 1957. As a part of this study, we have periodically examined three identically designed houses built at a Forest Service ranger station in Washington. For each house, framing material of a different moisture content was used--unseasoned, kiln-dried to 19 percent, and kiln-dried to 12 percent.

After 2 years of occupancy, the moisture content and dimensions of the framing in each house seem to have reached equilibrium with use conditions. One more set of observations at the end of the 1959-60 heating season should be sufficient to conclude the study. The West Coast Lumbermen's Association cooperated in selecting the test houses and is helping collect data.

Decay Hazards in Residential Structures

The Federal Housing Authority has requested the Forest Products Laboratory to evaluate decay hazards in residences throughout the country. The request has led to an exploratory study of 1 year's duration in which the moisture content of foundation framing members, porches, and exterior millwork will be determined in 200 to 300 houses. Wherever the moisture content of a wood framing member exceeds 20 percent, a potential decay hazard will be considered to exist; evidence of decay will be proof of the hazard. The survey was made in the East and South during the latter half of 1959 and will be extended to the Pacific Northwest in the spring of 1960.

PULP AND PAPER

A major problem of the Pacific Northwest's pulp industry concerns how to improve pulps from Douglas-fir. The more desirable pulp species of the region--including the hemlocks, spruces, and true firs--are in strong demand by existing pulp plants. On the other hand, the supply of lower cost Douglas-fir mill residues exceeds demand. Although current consumption of Douglas-fir in kraft pulp for paperboard, bags, and related products amounts to about 1-1/2 million dry tons of wood annually, the potential supply of Douglas-fir mill residue is double this amount. Thus, research to improve the versatility of Douglas-fir for a greater variety of paper products--by modification of pulping processes, pretreatment of

chips, segregation of raw material, or blending with other species--would create opportunities for improved forest management and consequent benefit to the region's economy. Industry, the Forest Products Laboratory, and other research agencies are working on aspects of this general problem.

Results of a study at Salem, Oreg., showed that water sprinkling of decked western hemlock logs in this area does not result in sufficient cooling of the logs to prevent decay. However, keeping the log surfaces continuously wet prevents decay development and subsequent loss in pulp yield for as long as two summers. Unsprinkled logs, similarly decked, were stored through one summer without developing serious decay. But when stored through a second summer without sprinkling, fresh logs developed enough decay to result in a pulp yield loss of 4 percent, and old logs--containing some decay when decked--suffered a pulp yield loss of 13 percent. This study was made in cooperation with the Forest Products Laboratory and an Oregon pulp company.

PACKAGING

Use of bin pallets for bulk handling of produce such as hard fruits and vegetables continues to expand rapidly. It is estimated that nearly 250,000 bins were used to harvest 25 percent of the 1959 apple crop in Washington, representing an investment of about \$2-1/2 million for bins alone. First commercial use of bins for bulk handling of apples in the region didn't come about until 1957, when 25,000 bins were used.

Formerly wooden boxes were used as picking containers and then repacked and used as shipping containers. Use of bin pallets in picking permits use of fiberboard shipping containers, which have certain advantages over wooden boxes for this purpose.

Because of the tremendous interest in bin pallets, we cooperated with the Tree Fruit Experiment Station at Wenatchee, Wash., to help establish a program of bin tests at the Forest Products Laboratory. Prototypes of several commercial bin designs have been evaluated by means of several rough-handling and impact tests. The Laboratory's report will show results of such design variables as (1) lumber versus plywood, (2) diagonal bracing versus no bracing, (3) interior- versus exterior-framing members, and (4) 2-way versus 4-way entry pallet bases.

PLANS FOR 1960

1. Continue lumber and veneer grade-recovery studies in the region for use in the timber appraisal-base project. Original or additional recovery data are needed for several softwood species, including Douglas-fir, western hemlock, western redcedar, noble fir, and Shasta red fir.

2. Begin a national log- and tree-grade project to establish adequate standards for measuring quality of standing Douglas-fir timber. Because of (a) the high value of the species, (b) the variety of end products produced, and (c) the extensive geographical distribution of the species, this is a complex, long-term project.

3. Cooperate with industry, the U.S. Forest Products Laboratory, and other research agencies--both public and private--in promoting development of equipment to nondestructively indicate the stiffness and strength of individual pieces of lumber.

4. Cooperate with industry, the Forest Products Laboratory, and other research agencies to develop adequate standards for end-glued dimension lumber. This may involve further research, performance tests on production runs, and development of quality-control methods in order to achieve acceptance.

5. Cooperate with national-forest administration and with industry to develop logging methods and equipment that will (a) reduce erosion damage and road construction cost in removing timber from steep ground or (b) efficiently handle small logs produced in thinning.

6. Complete collection of moisture-content and dimension data from test houses built with framing members at three different levels of moisture content. Complete measurements of maximum temperatures reached in wall and roof members of other test houses. Continue field inspections (a) of service performance of glued laminated bridge timbers and (b) of exterior paint performance on houses. Survey a minimum of 50 houses for existence of decay hazard.

7. Assist in the development of utilization research plans and projects in Alaska.

8. Improve liaison between industry and the Forest Products Laboratory by (a) distributing selected research publications, (b) encouraging technical group meetings, such as sawmill clinics, and (c) discussing individual research needs with industry management and technical men.

Range, Wildlife Habitat, and Recreation Research

In 1959, emphasis was given to the first field work for a comprehensive study of vegetation-game management on the South Silver Lake Deer Herd Range, in cooperation with the Oregon State Game Commission. We also gave major attention to studies of carbohydrate and nitrogen levels in bitterbrush on important game ranges in Washington. Other investigations dealt with the interrelations between big game, livestock, and timber production. And, the impact of recreation on these resources received limited study that will point the way to a more detailed analysis of recreation research problems in 1960.

MANAGEMENT OF LIVESTOCK RANGES

Weather and Forage Production

In 1959, the long-term grazing management study on the Starkey Experimental Forest and Range showed pronounced effects of weather on forage production and cattle weight gains. Cool weather in the early part of the growing season retarded plant growth. Also, an unseasonably hot period in July promoted early curing of forage and by mid-August dried up many stock water supplies that formerly had remained available throughout the grazing season. The loss of stock water adversely affected cattle distribution and uniformity of forage use. Consequently, cattle weight gains were poorer than in any previous season of record in the study.

Cattle Weight Gains

Cattle weight gains were strongly influenced by rates of grazing in 1959. Cows grazed at the conservative rate (10 acres per animal-unit-month) gained an average of 54 pounds during the season. At the intermediate rate (7.5 acres per a. u. m.) they gained an average of 25 pounds; at the heavy rate (6.5 acres per a. u. m.) they lost 19 pounds.

Calf gains showed similar relationships. During the 114-day grazing season, calves under the conservative, intermediate, and heavy rates of grazing gained 184, 167, and 148 pounds, respectively.

Under intermediate grazing, 77 pairs of cows and calves produced 2,612 pounds more than 94 pairs grazed at the heavy rate. In other words,

intermediate grazing outproduced heavy grazing by 62 pounds per animal unit during the 4-month season.

Variation in cattle weight gains between ranges grazed under deferred-rotation and those grazed continuously, each at three rates of use, has been so large that no clear-cut difference between systems can yet be detected. Neither has there been a definite pattern of interacting response between the two systems and the three rates of use.

RANGE CONDITION AND TREND

Comparison of Bunchgrass Ranges

In northeastern Oregon, two similar and adjacent grassland sites that have been located are among the best found to date for detailed study of changes in bunchgrass ranges with different grazing histories. Both sites are 4,100 feet in elevation, have 5-percent south slopes, and have very stony loam soils of the Rock Creek series. Average soil depths are 10 inches, which approaches the 12-inch maximum depth described for this series.

Area 1 vegetation is representative of a range in excellent condition on deeper soils of the Rock Creek series. It has not been grazed by domestic stock in the past 15 years. Formerly, sheep grazed across this unwatered area each year during late summer. Occasionally some trespass cattle use occurred in early spring.

Area 2 received heavy sheep use in the spring following snowmelt from 1956 to 1959. Annual use before 1955 is uncertain; however, it was used for many years as a bucking pasture for range bands.

Table 1 summarizes the vegetation characteristics of the two areas as determined by the loop-transect and clipped-weight methods.

Soil Survey

A soil survey of the Starkey Experimental Forest and Range has been completed. In addition to the soils described in last year's annual report, four new grassland soils were tentatively described and mapped. This information now provides a basis for better interpretation of soil-vegetation relationships on important grazing lands in the Blue Mountains.

Table 1.--Comparison of vegetation characteristics of an ungrazed and a grazed bunchgrass range in northeastern Oregon

Ungrazed area ^{1/}			Species	Grazed area ^{2/}		
Basal area index	Composition index	Weight, air-dry (per acre)		Weight, air-dry (per acre)	Composition index	Basal area index
-- Percent --		Pounds		Pounds	-- Percent --	
12	37	670	Bluebunch wheatgrass	305	23	5
16	49	100	Sandberg bluegrass	70	70	10
1	2	10	One-spike oatgrass	0	0	0
0	(3/)	40	Junegrass	0	0	0
0	(3/)	70	Hooker balsamroot	60	5	0
2	9	10	Bighead clover	0	(3/)	0
0	(3/)	10	Pale agoseris	0	0	0
0	1	10	Cous biscuitroot	15	(3/)	0
0	0	0	Western yarrow		(3/)	0
0	0	0	Rush pussytoes		(3/)	0
0	0	0	Low gumweed		(3/)	0
0	0	20	Annual weeds and grasses	180	0	0
31	100	940	Total	630	100	15

^{1/} Bare soil is 14 percent of the ground-cover index. Rock is 14 percent of the ground-cover index.

^{2/} Bare soil is 30 percent of the ground-cover index. Rock is 27 percent of the ground-cover index.

^{3/} Less than 1 percent.

Vegetation Recovery on Different Soils

Changes in floristic composition on three grassland sites were recorded after 17 years of protection from livestock use. Two of the sites have a complex of Rock Creek and Albee soils; the third site is limited to Ukiah soils. All three sites are similar in general land form and soil depth. However, one site (exclosure 1) is on a gentle northeast slope, with good lateral drainage; another (exclosure 2) is on a well-drained, 5- to 10-percent northeast slope; and the third (exclosure 3) is on a flat ridgetop, with poor lateral drainage. Exclosure 2 is limited to soils from the Ukiah series.

Major changes occurred among the grasses, with smaller shifts among the forbs. Changes in composition percent of five grasses were

found to be influenced by soil series as well as by drainage phases within soil series (table 2).

Table 2.--Grass components on three grassland soils
in eastern Oregon, 1942 and 1959

Species	Rock Creek				Ukiah		Albee			
	Good drainage		Poor drainage		Good drainage		Good drainage		Poor drainage	
	(Exclosure 1)		(Exclosure 3)		(Exclosure 2)		(Exclosure 1)		(Exclosure 3)	
	1942	1959	1942	1959	1942	1959	1942	1959	1942	1959
----- Percent -----										
Bluebunch wheatgrass	0	1	0	0	14	34	38	35	0	0
Idaho fescue	0	(1/)	0	0	(1/)	13	1	11	0	0
Junegrass	0	0	0	0	1	4	5	9	5	32
One-spike oatgrass	4	22	5	22	17	2	0	0	6	5
Sandberg bluegrass	29	26	39	35	37	18	5	11	44	10

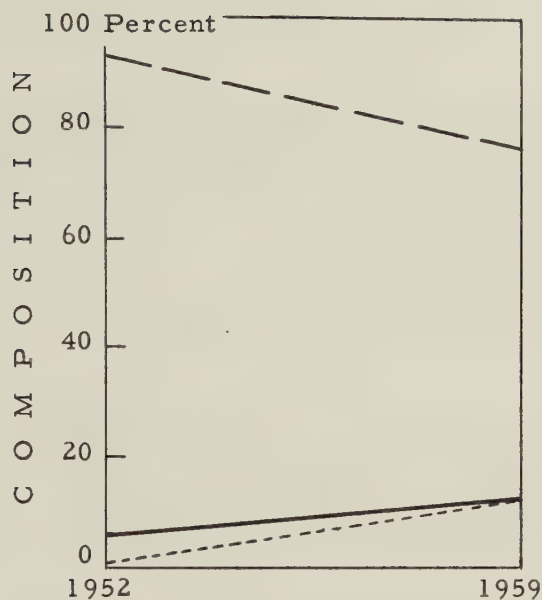
1/ Less than 1 percent.

These changes show the variability of recovery of grass species on different soils and on different phases of the same soils. With this new insight into some of the most prominent grassland sites in the northern Blue Mountains, we have a fresh basis for reinterpreting conditions on the so-called Umatilla ridges and for refining some of our range conditions standards.

Trend Measurement

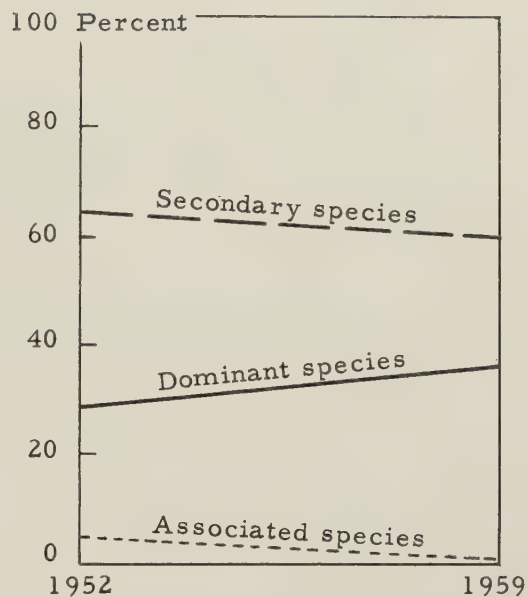
Seventh-year remeasurements of 27 loop transects on 4 open grassland sites at the Starkey Experimental Forest and Range show an upward trend in range condition. This confirms the trend noted in 1956, when nine transects were remeasured. The climax dominants--bluebunch wheatgrass and Idaho fescue--have continued to increase, whereas the secondary species--Sandberg bluegrass and junegrass--and some associated forbs have continued to decrease in the composition and cover of the sites. However, the rate of change in composition of the vegetation between 1952 and 1959 varied with soil-site conditions (opposite).

On a shallow Rock Creek soil, bluebunch wheatgrass increased from 6 to 12 percent in the composition. Sandberg bluegrass decreased from 63 to 54 percent and cous biscuitroot from 16 to 5 percent. The



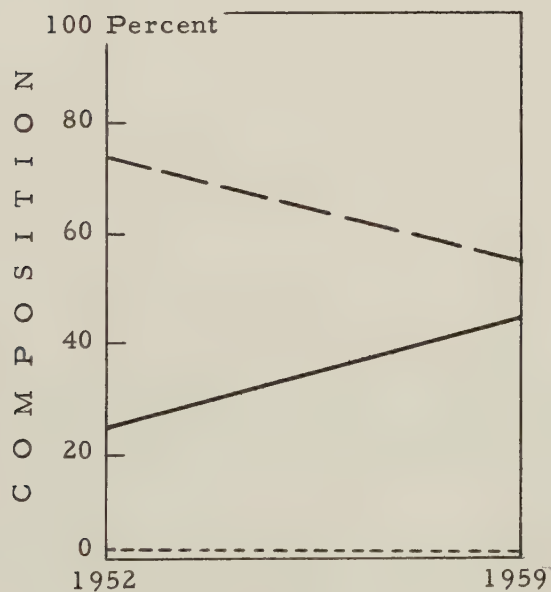
ROCK CREEK

SITE: Soil 8 inches deep, very stony.
0-5 percent northeast slope.



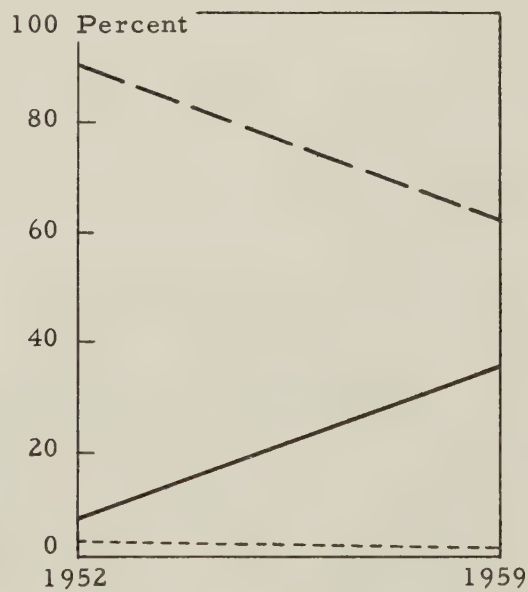
UKIAH

SITE: Soil 13 inches deep, stony heavy clay 2 to 6 inches thick above the bedrock.
5 percent east slope.



ROCK CREEK-ALBEE

SITE: Soil 15 inches deep, variable stoniness.
10 percent northeast slope.



WILKINS

SITE: Grassland meadow. Soil 12 to 16 inches deep, stony with heavy clay 1 inch thick above bedrock.
5 percent east slope.

invading Douglas stonecrop, an early maturing perennial, accounted for 10 percent of the composition in 1959.

On a stony, shallow-phase Ukiah soil, bluebunch wheatgrass increased from 29 to 35 percent. Idaho fescue became reestablished and was 2 percent of the composition. Sandberg bluegrass decreased 19 percent.

On a Rock Creek-Albee soil complex, Idaho fescue increased from 9 to 24 percent and bluebunch wheatgrass from 12 to 20 percent. Junegrass in 1959 was about the same in the composition as in 1952--7 percent. Sandberg bluegrass decreased 21 percent.

The greatest improvement was made on a meadow soil of the Wilkins series. Thin bentgrass increased from 6 to 32 percent of the composition, and Baltic rush--which becomes prominent with range degeneration on these soils--decreased from 34 to 16 percent. Sandberg bluegrass decreased from 42 to 32 percent.

These transect measurements show that range condition of primary grasslands has continued to improve under the cattle and range management program at Starkey. They further show the variation in rate of change of individual and ecologically grouped species on different soils, confirming the need for a clearer understanding of the ecology of range plants.

MANAGEMENT OF BIG-GAME RANGES

Deer-Range Relationships

Field work for the cooperative Silver Lake deer habitat study was concentrated on the ecological description of important habitat types on both the summer and winter range of the 400,000-acre study area.

Ten macroplots of a subsampling system were randomly located on each of six habitat types on the summer range. Winter-range measurements included five plots on one habitat type and two plots on each of four other types. Information from these plots will give us a preliminary description of the more important habitats and also will supply information, through statistical analysis, on the total number of plots per habitat that will be required for an adequate ecological description. Ultimately, this information will permit study of the relations between vegetation characteristics and forage utilization by deer.

Forage Utilization by Deer

Rumen samples from 17 mule deer were collected in the Silver Lake herd unit during October 1958 by the Oregon State Game Commission as part of the cooperative study. Information from these samples provided pertinent facts concerning foraging habits and food preferences of the animals at the time of collection. Composition--by percentage of total volume--of the rumen samples was:

<u>Food</u>	<u>Percentage of total volume</u>	
	(Range)	(Average)
Bitterbrush	1-100	61
Mountain mahogany	0- 90	11
Snowbrush ceanothus	0- 67	10
Creeping mahonia	0- 95	9
Manzanita	0- 16	1
Mushroom	0- 20	5
Lichen	0- 25	2
Forbs and grasses	(1/)	<u>1</u>
Total		100

1/ Traces.

Of interest is the relatively large amount of snowbrush ceanothus represented in the diet of some individual deer. In one case this deer forage of questionable palatability provided 67 percent of the rumen volume. This indicates that snowbrush may well be an important constituent of the diet under certain circumstances.

These data should be considered preliminary findings since diets of individual animals varied widely. Among other things, promiscuous grouping of samples collected in greatly different vegetation types and variable weather conditions contributed to this variation. Subsequent samples will be collected monthly from deer taken in specified vegetation types to provide for natural groupings.

Deer-Cattle Range Relationships

Where big game and livestock use the same area at the same time, it is often difficult to determine how much of the total utilization can be attributed to each class of animal. One commonly employed solution to this problem is the construction of two exclosures--one inaccessible to

all grazing animals, and the other inaccessible to livestock but accessible to deer and elk. A pair of such exclosures, constructed on the Okanogan National Forest in north-central Washington, illustrate the response of bitterbrush to use by both deer and cattle (below). The particular area involved is used primarily as summer range by cattle and as winter range by deer, although a small number of deer also summer there.



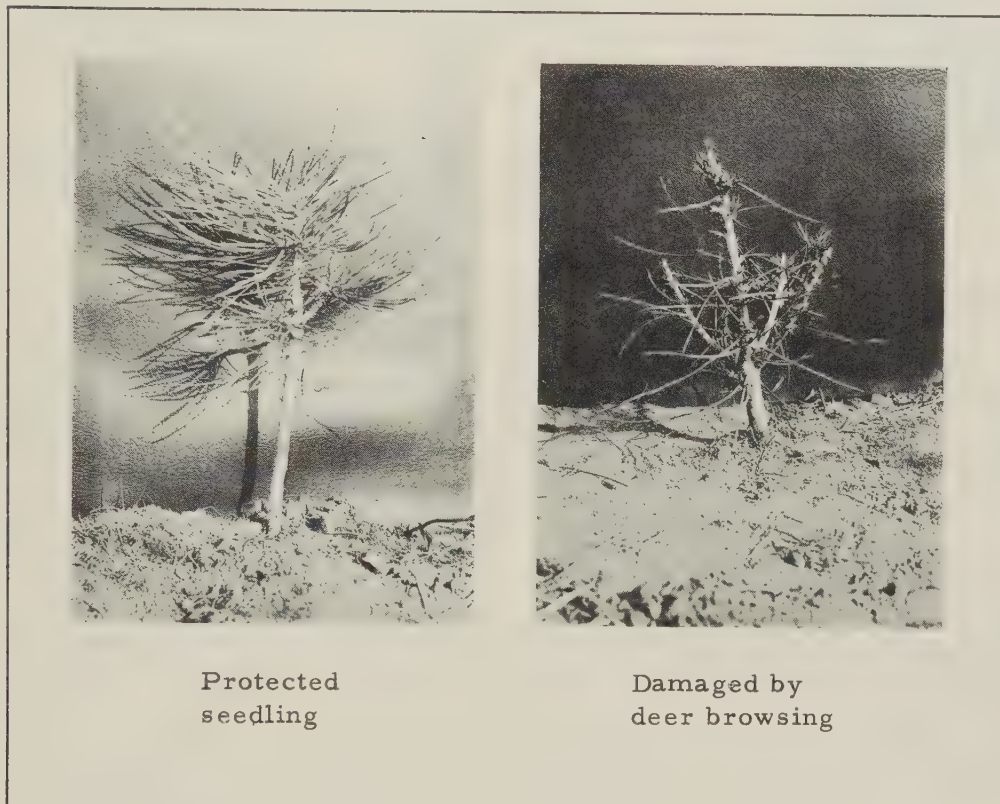
Unused by deer
or cattle.

3 years' winter
use by deer;
unused by cattle.

3 years' winter
use by deer; 4
years' summer
use by cattle.

Deer-Repellent Chemicals

Browsing by deer on ponderosa pine seedlings continues to be a serious problem in the pine subregion (below). In central Oregon, we are



testing three chemicals--ZAC, TMTD, and copper omadine--and protective cover brush for effectiveness in reducing browsing. Treatments were made in April 1958. By January 1959, 33 percent of all 900 tree seedlings used in the study were dead or missing. Only 7 percent of the remaining 606 trees had been browsed by deer. Of that 7 percent, 3.4 percent were control trees with no treatment, 2.4 percent were trees with brush cover, and 1.2 percent were trees that had been chemically treated--0.4 percent in each of the three treatments. Results to date from statistical analyses show no significant differences between treatments and control at the 5-percent level of probability. Observations show that seedling mortality is much higher where they were not covered by brush. This is probably due, among other things, to much higher soil surface temperatures and greater transpirational stress occurring in those plots not covered by brush.



Pocket gophers destroyed 8.5 percent of all seedlings by chewing away the bark (left). This type of damage is much more serious than was expected at the beginning of the study.

To date very little animal damage has been done during the late spring and summer months; most has occurred during the winter and early spring.

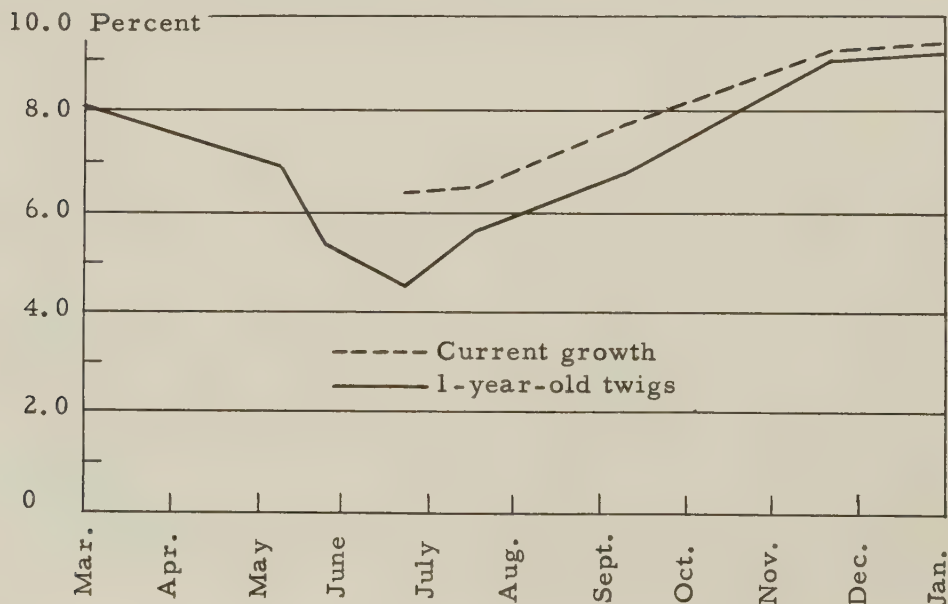
ECOLOGY AND PHYSIOLOGY OF RANGE PLANTS

Carbohydrate Reserves in Bitterbrush

Perhaps no technical problem is of greater concern to range managers than food manufacture and storage in key forage species and how these operations are influenced by season and intensity of use. A number of investigations have been made on food reserves in grasses, but browse species have received only limited attention.

Tentative results from a study of seasonal trends in available carbohydrates in bitterbrush near Wenatchee, Wash., indicate that stored reserves are lowest in current and 1-year-old materials during the seed development-initial twig growth stage (below). A high level of storage is reached by time of leaf fall and maintained through midwinter, with no

AVAILABLE CARBOHYDRATES



apparent translocation of reserves to storage areas in other parts of the plant. The average standard error, based on incomplete laboratory analysis of all plants collected, is 0.22 percent for 1-year-old twigs and 0.42 percent for current growth for the combined sampling periods. Larger top materials have not as yet been analyzed.

A partial analysis of bitterbrush roots indicates that available carbohydrates may be expected to vary from approximately 13 percent in spring dormancy, to a low of about 6 percent at seed maturity, to a high of nearly 15 percent in the fall.

Effects of Gibberellic Acid and Cold Treatment on the Germination of Bitterbrush Seed

With proper seeding-depth control and protection from rodents, germination and emergence of bitterbrush seed is normally satisfactory in central Washington. During the dry summer growing season, however, mortality of seedlings is often extremely high--presumably the result of their inability to compete for limited soil moisture. Consequently, the growth promoting qualities of gibberellic acid are being investigated as a means of assisting seedlings through these periods of critical soil-moisture stress. The combined effects of the acid and cold stratification on germination of bitterbrush seed were tested as a preliminary step in this investigation.

Table 3 shows germination percent of bitterbrush seed for a series of cold and acid treatments. Differences between responses to cold treatments, acid treatments, and the interaction between cold and acid treatments were all highly significant. Comparisons in regression for both cold and acid indicated that significant relationships also exist between treatment levels and responses.

Table 3.--Germination percent of bitterbrush seeds after a series of cold-stratification and gibberellic acid treatments

Cold treatment (days)	Gibberellic acid (p.p.m.)							
	0	25	50	100	200	500	1,000	Average
0	5.3	7.3	9.0	8.0	19.7	20.7	38.7	15.5
7	17.0	24.3	20.3	25.3	30.3	48.0	53.7	31.3
15	49.7	50.7	54.0	50.7	72.0	81.7	85.3	63.4
30	86.7	88.3	83.7	85.0	86.0	90.0	92.7	87.3
Average	39.7	42.4	41.7	42.2	52.0	60.1	67.6	--

In general, the time required for germination was inversely proportional to acid concentration, except for the 30-day cold treatment. Many seedlings receiving no cold and 7-day cold treatment germinated slowly and were adversely affected by gibberellic acid. Survival of such deformed seedlings appears questionable; however, growth response of seeds subjected to 15- and 30-day cold-stratification and selected acid treatments merits additional study.

Seasonal Trends in Forage Quality

A preliminary study of seasonal fluctuations in the nutrient content of the four principal forage species on forested summer range was made in the Blue Mountains near La Grande, Oreg.

Two species, bluebunch wheatgrass and Idaho fescue, occur in the grassland openings as well as in the open forest pine-bunchgrass subtype. Fodder analysis for both species under each situation was studied and compared. Also assayed were two additional species, pinegrass and elk sedge, both found only under forested conditions. Components of the analysis included crude protein, phosphorus, fat, lignin, sugar, and starch.

Protein content of each species declined considerably throughout the grazing season (table 4). By early August, forage protein content had dropped below the recommended minimum for nutritional needs of cattle (5 percent). Weight gains of cows grazing in the areas from which the nutrient samples were collected readily reflected this drop in quality; 90 percent of their gains were made before August 1.

Table 4.--Seasonal trends in digestible protein content of several important forage species on mountain summer range
(In percent)

Type and species	Date of observation					
	July 1	July 20	Aug. 9	Aug. 29	Sept. 18	Oct. 18
Grassland:						
Bluebunch wheatgrass	6.1	5.7	3.6	3.3	3.3	2.1
Idaho fescue	4.8	4.6	3.1	2.8	3.5	3.1
Forest:						
Bluebunch wheatgrass	6.0	5.8	4.1	3.4	3.1	2.8
Idaho fescue	5.0	4.8	3.1	3.4	3.0	2.9
Elk sedge	5.4	5.2	4.4	4.3	4.2	3.1
Pinegrass	6.2	5.9	5.2	4.2	2.8	1.6

Grasses differed as to their seasonal variation in protein content. During early grazing season, wheatgrass contained a higher protein content than fescue; however, a reversal occurred later in the season. This was particularly evident in the grassland type. Among the species in the forest, pinegrass began the grazing season with the highest protein content, yet ended with the lowest; while elk sedge, probably due to its ever-green habit, maintained its content relatively well during late season.

With the exception of sugar content, cover type induced little or no nutrient change in any grass. Wheatgrass and Idaho fescue sampled under forested conditions did show significantly higher sugar content than the same species collected in the grassland openings for the same periods.

Phosphorus levels were maintained well above the recommended minimum maintenance allowance of 0.15 percent, except in bluebunch wheatgrass. During late grazing season, after October 1, the phosphorus content of wheatgrass dropped to 0.14 percent. Of the species observed, fescue of the forested type maintained the highest phosphorus level throughout the season. It decreased from approximately 0.50 percent on July 1 to approximately 0.25 percent on October 20.

Effects of Clipping Elk Sedge

Removal of 60 percent of the current herbage growth of elk sedge in the Blue Mountains decreased production in the second year of clipping. This effect was obtained by clipping at any time up to and including the period of seed dissemination. The study indicates that only in early fall, after root reserves have been replaced, can this much herbage be removed without harm to elk sedge.

Removal of 40 percent of currently produced herbage of elk sedge did not decrease herbage production until the 5th year of clipping. The effect was produced by clipping just before seed dissemination. Apparently, occasional use at the 40-percent level is not detrimental to elk sedge.

Changes in heights and numbers of seed stalks were the first signs of changing vigor. After 1 year's treatment, seed stalks of the plants that were clipped 60 percent were significantly shorter and fewer in number than stalks clipped 40 and 20 percent. These indicators could very well serve to justify change in use before permanent damage to the plant occurs.

NEW CODING SYSTEM FOR RANGE PLANTS

Increased use is being made of automatic data-processing machines. If range plant scientists and ecologists are to take advantage of the new tools for analysis of plant communities and range survey data, plant nomenclature must be adapted to requirements of the machines. Consequently we have devised a four- to five-character alphabetical code and a six-digit numerical code for names of forest and range plants in Oregon and Washington. Development of both types of codes was necessary to give prospective users the choice between data-processing machines that can only handle numerical codes and machines that can handle either numerical or alphabetical codes.

Below is an excerpt from the new coding system:

<u>Alpha code</u>	<u>Numeric code</u>	<u>Scientific name</u>	<u>Common name</u>
PENNI	036,000	Pennisetum spp.	Pennisetum
Pegl3	001	Pennisetum glaucum	Pearlmillet
PHALA	037,000	Phalaris spp.	Canarygrass
Phar	001	Phalaris arundinacea	Reed canarygrass
Phca	002	Phalaris canariensis	Canarygrass
PHLEU	038,000	Phleum spp.	Timothy

The code lists about 2,500 species and varieties collected on national-forest lands in Oregon and Washington.

RANGE MEASUREMENT TECHNIQUES

We used the spherical densiometer, a gridded convex mirror, on the Silver Lake deer habitat study to estimate shrub and tree cover above a line transect. By holding the densiometer above the transect tape and dropping an attached plumb bob past the tape (below left), reflected crown overstory can be read directly as crown intercept.



A time study was made to determine the efficiency of this method. Eight 100-foot transects through mountain mahogany were measured at an average rate of 4.12 feet of actual crown foliage per minute. This compares favorably with a rate of 4.43 feet per minute for the plumb bob method in bitterbrush—

sagebrush, sagebrush-bitterbrush, sagebrush, and rabbitbrush. The densiometer method can be used with equal success on other overstory species such as ponderosa pine, white fir, juniper, and willow.

PLANS FOR 1960

No major changes in range and wildlife investigations are contemplated for 1960. We will emphasize prompt publication of research results, more thorough program planning, and an analysis of recreation research needs in the Pacific Northwest. A few examples of research tasks to be undertaken include:

1. Compilation of survey data and vegetation measurements made over the past 5 years on the Starkey Experimental Forest and Range.
2. Preparation of manuscripts summarizing vegetation changes caused by management of high-altitude sheep ranges in the Wallowa Mountains.
3. Completion of a composite type map of the Silver Lake Deer Herd Range for the central Oregon deer-habitat study, and sampling of types to determine the amount, season, and intensity of forage use by deer on seasonal ranges.
4. Completion of initial phases of a range-condition classification of 10 habitat types in the juniper area of central Oregon.
5. Completion of the study on use of chemical spray repellants for reducing deer-browsing damage to ponderosa pine seedlings.
6. Continuation of bitterbrush investigations, including the seasonal trend of carbohydrate reserves and nitrogen in this forage plant.
7. Analysis of forest recreation in Oregon and Washington and preparation of a proposed program of studies.

Watershed Management Research

Attention centered on two major categories of watershed management research in 1959: studies dealing with erosion and those concerned with the relation of vegetation to water supply.

Many people are beginning to realize that soil is one of the multiple values found on forest and range lands, and they are becoming concerned about losses through erosion. Effects of logging, for example, continue to stir interest in the Pacific Northwest. Opinions differ regarding the impact of logging on watersheds in terms of erosion, sediment load in streams, and disturbance of stream channels. Detailed studies are needed to replace conjecture and to provide sane and practical measures for minimizing damage from logging where damage occurs. Some progress on logging erosion studies was made during 1959.

Water is another essential resource of forest and range lands. Not too many years hence, few progressive land managers will cut timber, build roads, graze cattle, or lay out recreation sites without considering impacts on water supply. This is why it is essential now to learn more about how vegetative cover, soils, and land use affect waterflows. These objectives prompted us this year to begin several studies of factors causing loss of moisture in the soil mantle.

EROSION

Forest Roads

Last summer marked the first step in a detailed study of logging roads in the H. J. Andrews Experimental Forest. In a 250-acre experimental watershed, 1.7 miles of road were built to prepare for logging a quarter of the watershed by the staggered-setting system. Design and construction problems typify those found in much of the steep topography now being logged in the Cascade and Coast Ranges of Oregon and Washington. The timber purchaser built the roads to standard specifications and in accordance with normal Forest Service sale requirements.

Our objectives are to make detailed observations of soil loss and to trace changes in volume of streamflow and timing of peak runoff. For 6 years prior to road building we have been measuring runoff and sampling sediment content in the stream. Changes caused by road building can therefore be readily recognized. We hope to pinpoint characteristic problems and seek practical means of averting or correcting them. A second phase of the study in this experimental watershed--logging by the high-lead

system--will be postponed for 2 years while the effects of road building are being observed.

The first concern is the area occupied by the road. A survey showed slightly more than 6 percent of the total 250-acre drainage exposed in the following ways:

<u>Type of disturbance</u>	<u>Area disturbed</u>	
	(acres)	(percent)
Roadbed	5.1	2.0
Backslopes	2.5	1.0
Fillslopes	<u>8.0</u>	<u>3.2</u>
Total	15.6	6.2

Roads were required at three elevational levels in the watershed for ease of logging and future management of the area. On the upper and lower levels, where topography is gentle, average widths of disturbance were 52 and 60 feet, respectively. For the middle road, which is located in steep topography and crosses two stream channels on large fills, disturbances averaged 94 feet in width, even though backslopes were deliberately steepened to reduce the area of exposed soil.

It is already apparent that road construction has affected erosion and stream siltation. The first fall rains, unusually heavy in 1959, began in September immediately following construction. Intensities in excess of three-fourths inch per hour created a small mudflow into the main creek, resulting in suspended sediment loads of more than 1,700 parts per million at the gaging station 0.6 mile downstream. An adjacent untreated watershed remained clear, with not more than 22 p.p.m. During the 6-year period before construction, sediment loads had never exceeded 200 p.p.m. in either watershed, even during much heavier rains.

The source of sediment was confined to one 50-foot section of the middle road near a channel crossing, where topography is steep. Soils here are derived from volcanic deposits, high in clay and silt fractions, which seem to "melt" under heavy rains. The upper and lower roads, where topography is more gentle and construction was easy, produced no sediment that reached the stream.

These preliminary results indicate that siltation can stem from a relatively small part of a road. If it proves feasible to recognize these trouble spots in advance of construction and apply preventive measures, a substantial amount of road erosion could be averted.

Road banks are one source of potential trouble. Erosion from side cuts often fills ditches, plugs culverts, and diverts water across the roadbed.

A study of this problem has been undertaken in cooperation with the Bureau of Land Management and Oregon State College. Results show that a surprising amount of soil movement occurs as dry ravel during summer months. Frost heaving can also contribute to loosening of the soil, making it subject to movement by water or gravity. On existing roads at H. J. Andrews Experimental Forest, soil movement attributed to all causes during a 1-year period has occurred at rates as high as 80 tons per acre of cut bank.

Because grass is credited with ability to protect against frost heaving, dry ravel, and surface-water erosion from cut banks, we have sought means of establishing an effective cover. In Bull Run watershed--source of domestic water for Portland, Oreg.--it has been demonstrated that fertilizer greatly increases chances of successfully establishing grass cover. Several miles of road banks were mulched, then seeded and fertilized with 16:20:0 fertilizer applied at rates of 100, 300, and 500 lbs. per acre. Observations point clearly to the effectiveness of the highest rate of

application (left). Grass did not become established on an adjacent unfertilized road bank, even though it was heavily mulched and seeded (below). Although an adequate cover may sometimes be obtained without the use of fertilizers, the evidence clearly validates their use.



Skidroads

A study of skidroad erosion in southwestern Oregon has demonstrated the care needed in evaluating measurement data. First-year results have shown that cross-section profile measurements can lead to inflated values of soil loss, primarily because of settling that occurs in the deep dust layer prevalent on newly developed skidroads. This error ranges from 400 to 900 percent, based on volumes of eroded soil obtained from the same plots by catchment devices.

Results from four of these runoff plots also emphasized large variability in skidroad erosion, as illustrated by data from two representative plots. They are similar in length, area, and slope and are located within 200 yards of each other on the same soil type. However, one plot (No. 6), is on a road and received much heavier use; soil lost during the first season after logging was about seven times that lost from plot 2 (table 5).

Table 5.--Soil loss from two skidroad plots

Plot number	Plot characteristics			Runoff	Soil loss
	Area	Length	Slope		
	<u>Square feet</u>	<u>Feet</u>	<u>Percent</u>	<u>Gallons</u>	<u>Cubic feet</u>
2	963	76	35	6,500	2.7
6	1,040	80	36	15,000	19.9

Skyline Logging

Several modern forms of skyline logging offer promise of minimizing erosion on steep slopes because they reduce need for haul roads and skidroads. Two such systems have operated on a trial basis in the Pacific Northwest--a Swiss-developed skyline crane and, more recently, an American-made machine of similar principle.

Key component of these systems is the carriage, which travels on a skyline cable and transports suspended logs from yarding point to landing. Because the carriage is normally out of reach, some type of remote control is necessary.

In the American-made version, now operating in a timber sale near Darrington, Wash., the carriage is controlled electronically. In response to a radio signal from the ground, a 95-horsepower diesel motor



in the carriage operates a yarding cable, raising a load of logs and suspending it at the desired height while the carriage travels down the cable by gravity to the landing (left). At the landing, another signal causes the load to be lowered.

Plans are being made to use one of the new skyline systems on a small experimental watershed at the H. J. Andrews Experimental Forest. Objectives are to obtain precise measurements of any erosion resulting from logging by this method and to make a careful analysis of costs. The study will be a companion to the one started this year to measure effects of roads and logging by conventional high-lead methods.

Debris in Channels

During the past year we have tried to learn more about the effect of logging debris on erosion of stream channels. One problem is to predict how much water will flow in any given stream channel during periods of peak runoff. An important factor in this estimate is the size of the drainage area contributing the flow. From experience at H. J. Andrews Experimental Forest, it is relatively easy to determine a rough relationship for typical drainages on the west side of the Cascade Range:

<u>Area of drainage</u> (acres)	<u>Maximum discharge</u> (cubic feet per second)
40	8
50	10
100	20
400	80
640	128

A second factor is the volume of water at any given point in the stream because this influences extent of bank scour. For the same rate of discharge, volume will change inversely with velocity of flow. Because mountain streams are so variable in gradient and contain so many obstructions to flow, it is difficult to determine typical velocities.

We are attempting to do this, however, at the H. J. Andrews. Repeated measurements are being taken in sections of five stream channels to determine range of velocities for varying rates of discharge.

Unstable Soils

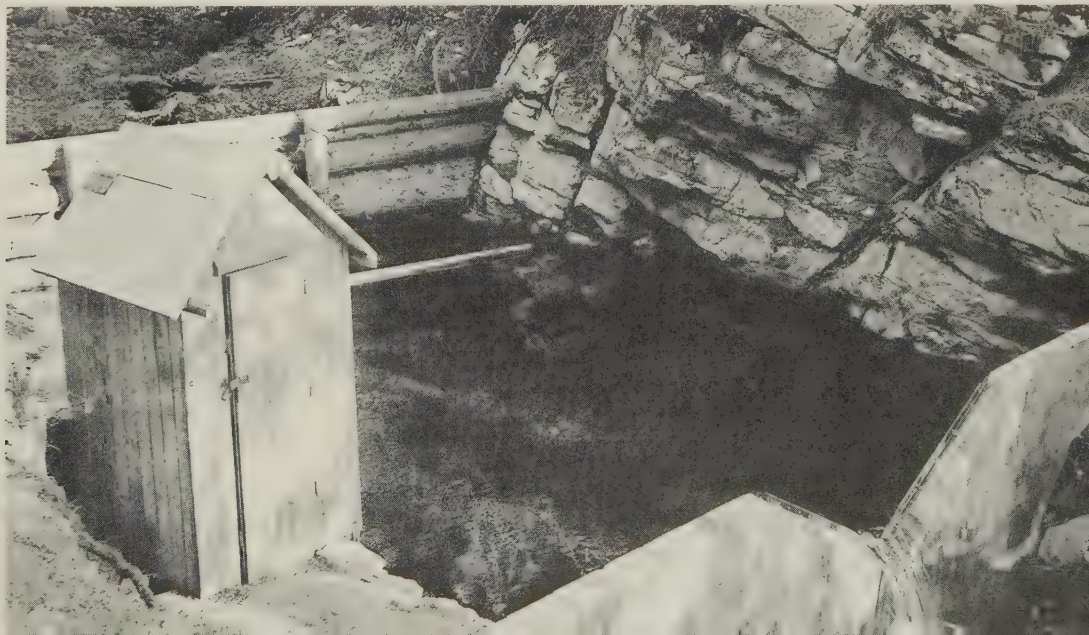
In 1958, check dams were built on three small eroding watersheds (1 to 3-1/2 acres) in a tributary of Mission Creek near Wenatchee, Wash. During the past year, soil erosion from the three watersheds totaled 1.97, 1.41, and 1.88 tons per acre. These amounts may be lower than average because summer thunderstorm activity during the past year was considerably below normal. Maximum rainfall intensity was 0.2 inch per 15-minute period, whereas rainfall intensities eight times this amount have been recorded in this area.

FOREST COVER AND STREAMFLOW

Watershed Studies

Six years of streamflow records from the H. J. Andrews Experimental Forest and data from other studies permit determination of an approximate water balance for a typical old-growth Douglas-fir forest. Average annual precipitation is 92 inches, of which 65 percent becomes streamflow. Tree crowns intercept 12 percent of the annual precipitation--an amount subtracted from gross precipitation before it reaches the ground. Evaporation and transpiration account for the remaining 23 percent, most of it moisture taken from the soil by vegetation. Studies to determine how logging will influence this water balance have been started on one of the experimental forest's three small test watersheds.

Similar information is needed in other major vegetative and climatic zones of the Pacific Northwest. Last year, progress was made on two watershed studies, one of which is located in southwestern Oregon. The second study is located in the Entiat River drainage on the east slopes of the Cascade Range in Washington. During the past summer a 120° V-notch weir was installed on Burns Creek (below), a 2.5-square-mile watershed



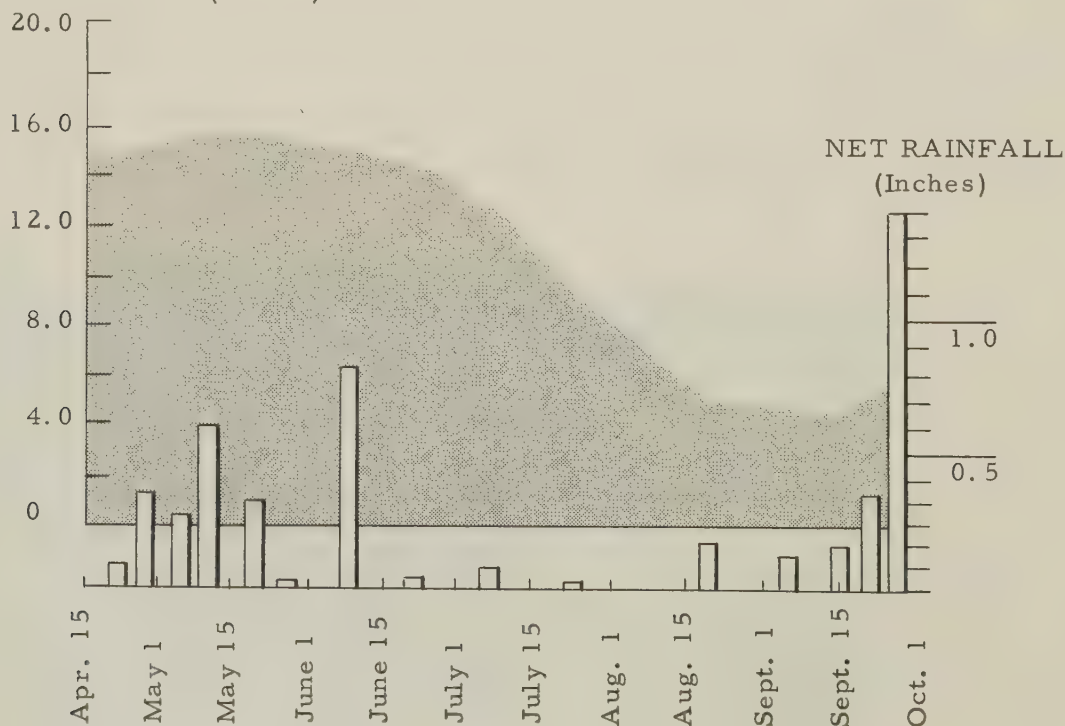
typical of soil, topography, and timber types covering extensive areas of forest land in north-central Washington. Soils are formed from acid igneous granites and grano-diorite parent materials, and are generally shallow and erosive. Topography of the watersheds is steep, with elevations ranging from 3,000 to 7,000 feet. Lower elevation timber types are ponderosa pine, with transitions through pine, Douglas-fir, and true fir to lodgepole pine and subalpine species at the ridgetops.

Data now being collected will be the first detailed record of water yield and sediment movement for these specific soil and vegetative types. Similar installations are planned for two adjacent watersheds. After basic hydrologic studies are completed, we will use these drainages to study the effects of timber cutting and cutting techniques.

From one season's observation, it appears that about one-fourth of the total summer rainfall is intercepted by lodgepole pine canopies. Only negligible amounts of intercepted rainfall normally flowed down the tree boles into stemflow gages. Probably most of the intercepted rain was dissipated by evaporation from the tree foliage.

Average water in the soil, expressed in inches of depth, ranged from 15.8 inches at the beginning of the growing season to 4.4 inches at the end (below). No surface runoff was observed during this period, indicating that all of the net rainfall (3.36 inches) entered the soil. Assuming

SOIL MOISTURE (Inches)



that all water in the soil was accounted for, evapotranspiration losses during the selected growth period of May 1 to September 17 can be expressed by the following relationship:

$$\text{ET} = (\text{Average soil-moisture depth, May 1; minus} \\ \text{average soil-moisture depth, September 17}) \\ \text{plus net rainfall for the measurement} \\ \text{period.}$$

$$= (15.8 \text{ in. minus } 4.4 \text{ in.}) \text{ plus } 3.4 \text{ in.}$$

$$= 14.8 \text{ in.}$$

Soil Moisture

Soil moisture studies are needed in major soil and vegetative types to fully understand the effects of forests on streamflow. Consequently, we began measuring soil moisture in several places to supplement knowledge gained from experimental watersheds. In the Bull Run watershed, near Portland, data are being collected on both forested and clear-cut areas. A similar study was started in the South Umpqua River drainage, where soil and vegetative cover types are representative of those found in a large part of southwestern Oregon. Results will indicate the magnitude of change in streamflow that can normally be expected when timber is cut.

In the Blue Mountains of eastern Oregon, we are learning how much water is lost by evaporation and transpiration in lodgepole pine stands during the growing season. This summer we traced moisture losses in stands growing on soils developed from basalt. A typical profile is made up of 1 to 2 feet of residual soil topped by approximately 2 feet of windblown pumicite, a fine ashlike material. Biweekly measurements from May 1 to October 1 included soil moisture, gross precipitation, and net precipitation (under the tree crowns).

Two lodgepole pine root systems were excavated as part of the soil moisture study (below). Roots were mapped to trace their development in relation to layers of soil materials. In the stands examined, vertical development of roots was restricted, but lateral roots were abundant and extended outward from the bole as far as 21 feet through the layer of pumicite. The high proportion of roots in this layer can be partly



explained by two soil-moisture characteristics: the silty, wind-transported pumicite is very receptive to water, and all water stored in this zone is readily available for plant use.

PLANS FOR 1960

Erosion

1. Arrange a demonstration of skyline logging on the H. J. Andrews Experimental Forest and continue measuring effects of road building on erosion.
2. Continue the study of skidroad erosion in southwestern Oregon.
3. Describe channel characteristics and measure velocities in sample streams of western Oregon as a basis for determining hydraulic characteristics affecting movement of channel debris.

Forest Cover and Streamflow

1. Analyze effects of road building on streamflow in the H. J. Andrews Experimental Forest. Continue studies of water balance to improve knowledge of the distribution of precipitation in Douglas-fir and lodgepole pine forest types.
2. Design four stream gages and sediment-measuring installations for selected experimental watersheds in the South Umpqua Experimental Forest and build one installation. Install a stream gage in McCree Creek adjoining the Burns Creek experimental watershed (Entiat River drainage).
3. Continue soil-moisture measurements in four localities: Bull Run Watershed, H. J. Andrews Experimental Forest, South Umpqua River drainage, and in the lodgepole pine type of the Blue Mountains.
4. Continue examination of root development in lodgepole pine.

Forest Disease Research

Continued application of the multiple-use concept raises new problems of immediate economic importance. For example, upper-slope types have heretofore been useful chiefly for watershed protection, recreation, and wildlife, but must now be developed for timber production to meet urgent needs for raw materials. If this development is to be efficient and without damage to the basic resource, information is needed--and needed soon--about such things as the effect of logging injuries on advance reproduction and the extent of heart rots in commercial timber in these types.

These problems involve only a single use, and are simple compared with some that will be encountered when two or more intensive uses must be harmonized on the same acre. Nevertheless, their solution requires diversion of effort and consequent postponement of results from going projects. The situation is eased to some extent by gradually increasing financial support for forest disease research, but even a fourfold or fivefold increase would be inadequate to meet needs fully. Research programs, consequently, must be carefully balanced to permit attention to the new problems that accompany multiple-use management, without complete disruption of long-term studies already underway.

DECAY IN TRUE FIRS IN UPPER-SLOPE TYPES

Logging Wound Infections in Advance Reproduction

The value of advance reproduction on upper-slope clearcuts is often questioned because of disease possibilities. Decay losses are known to be severe in wounded hemlocks and true firs of merchantable and near-merchantable size; wounds on saplings (right) and small poles, however, are usually so small and heal so rapidly that decay hazard appears to be slight.



We obtained the following results from dissections of Pacific silver fir on two clearcuts, 8 and 9 years old, at elevations of about 3,000 feet:

	<u>Randle</u>	<u>Wind River</u>
Trees (number):	19	28
Average age (years)	69	86
Average height (feet)	14	11
Average growth since logging (feet)	8	5
Logging wounds (number):	29	46
Average original area (square feet)	0.1	0.1
With heart rot (number)	1	2

More than half of the wounds were fully callused. Presence or absence of heart-rot fungi was determined by culturing as well as by visual inspection. All decay found was in the incipient stage.

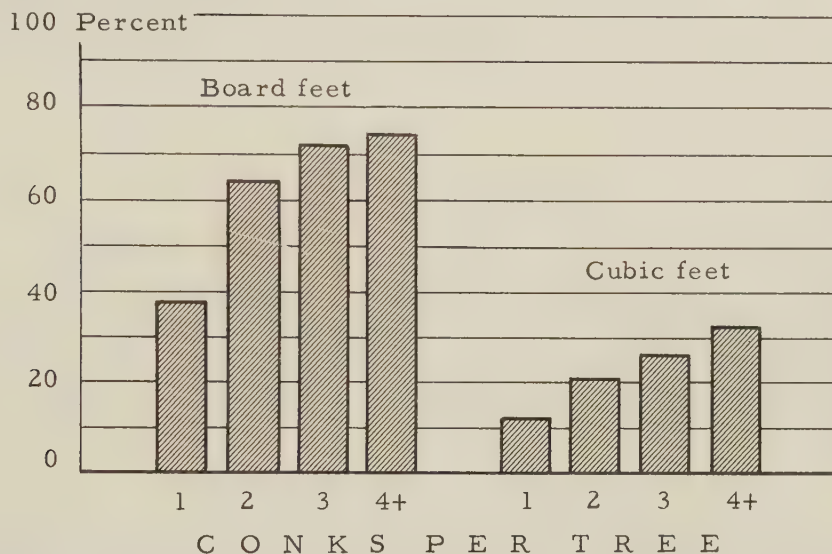
At rotation size, stands from advance reproduction will be older--and perhaps as a consequence somewhat more decayed--than stands that have never been suppressed. Other diseases, and especially dwarfmistletoes, must also be considered. Nevertheless the above results strongly suggest that satisfactory stands can often be obtained, without the costs and hazards of planting, by preservation of advance silver fir reproduction, even where logging scars are common.

Heart Rot in Mature Trees

Rules for estimating decay in standing timber vary from one locality to another, but the most common rule is to cull the entire tree if it bears an Echinodontium tinctorium conk. Dissection of 7 white firs and 15 grand firs on 11 fifth-acre plots in a single locality in northeastern Oregon, indicates that even the more conservative rules may at times

considerably overestimate the extent of decay (below). Of the trees in this study, only 6 contained no sound board-foot volume and only 12 were cull according to present utilization standards. The average tree was 26 inches d.b.h. and 197 years old, with a gross volume of 920 board feet. Decay differences between white and grand firs were slight.

ECHINODONTIUM HEART ROT GROSS VOLUME



The percentages shown in the graph are based on only a small and local sample, and they include no allowance for decay in trees without conks or for decay caused by other fungi. Nevertheless, these results clearly show that indiscriminate and arbitrary application of cruising rules to individual trees during logging will result, at least at times, in waste of large volumes of merchantable wood.

DWARFMISTLETOE ON PONDEROSA PINE

Infected overstory trees are known to be serious infection hazards to nearby young growth. However, during recent surveys on old clearcuts, we found infection of young growth on or near only 50 percent of 612 sample plots within 1 chain of infected overstory residual trees. Most of the uninfected plots were moderately to well stocked, and most of the infected residuals bore vigorous dwarfmistletoe plants. This information is itself of little direct practical value, but it suggests a promising line for further research. Good methods for recognition of infected but noninfectious trees would permit reduction of control costs as well as greater flexibility in management of all-aged stands where dwarfmistletoe is a problem.

ROOT DISEASES

Poria weirii was found damaging mixed conifer stands in the Blue Mountains. It is now known to occur throughout the Pacific Northwest in all major coniferous types except pure pine and pure western hemlock. Although the extent of its damage has not been measured in most forest types, it continues to appear most destructive in pure Douglas-fir stands.

Port-Orford-cedar root rot continues to invade the natural range of its host and to intensify at established infection centers, even on slopes well above the river bottoms. Its steady progress indicates that damage to commercial stands will probably be occurring within 10 years.

DROUGHT INJURY

Common and conspicuous symptoms of drought injury appeared on sapling and larger trees during 1959. These symptoms consisted principally of simultaneous flagging of many twigs and branches previously injured by other causes, dying of unsuppressed lower branches, premature death of older foliage throughout the crowns, and top-killing of small poles on marginal sites (below). In spite of their alarming appearance, these



conspicuously injured trees represent little real damage. Economic loss to date has probably occurred principally in trees without conspicuous symptoms, and consists largely of decreased growth. Some additional loss must also be expected from weakening of trees on productive sites to the point where they may be easily attacked by root rots, insects, and other enemies.

Several hundred acres of new plantations were lost during the spring of 1959 as a result of two periods of unusually dry, windy weather while seedling roots were still dormant. Injury appeared to have been aggravated by unfavorable top-root ratios.

ANTIBIOTICS

Tests on sugar pine in Oregon have proved Actidione as effective against blister rust as it was earlier found to be on white pine in the Northern Rocky Mountain region. Tests of antibiotics for control of other diseases on other hosts, started in 1958, have been inconclusive because of unexpectedly high toxicity to the trees and weather generally unfavorable to the diseases.

PLANS FOR 1960

1. Continue long-term studies of needle blight and other major diseases.
2. In root disease studies, give increased attention to fundamental problems.
3. Explore possibilities of collecting dwarfmistletoe growth-impact data, needed for economic analyses of costs and benefits of control.
4. Extend studies of decay in upper-slope types to at least one additional locality.
5. Extend antibiotic tests to include other compounds and other diseases.

Forest Insect Research

For the northwestern forester, frequently plagued by insect outbreaks, 1959 was a good year because it brought no major insect crisis. This also made it a good year in insect research because planned studies and surveys could be carried out as scheduled. Consequently, substantial progress was made in our program.

Discovery of the European pine shoot moth in the State of Washington posed the problem of what to do about this potential threat to young ponderosa pine. Spruce budworm populations continued to decline, as did damage by the balsam woolly aphid. Mountain pine beetle killing of ponderosa pine increased.

For the third successive year, we imported foreign insect predators to combat the balsam woolly aphid. Four species have become established, and two already show promise of being effective natural control agents.

Research is gradually improving methods for determining control needs. For example, accumulated findings now make it possible to evaluate the biological status of spruce budworm populations with considerable confidence. Thus the need for control can be judged more on the damage the insect is likely to cause than on the damage already caused.

SURVEYS AND CONTROL

Cooperative surveys of insect conditions in Oregon and Washington followed the established pattern of making a comprehensive aerial survey of the entire region and then evaluating insect populations by ground checks. Epidemics in 1959 covered next to the lowest acreage for the nine consecutive years for which records are complete. Insects recorded as epidemic were:

	<u>Acres</u>
Defoliators:	
Spruce budworm	209,280
Ponderosa pine needle miner	16,480
Larch bud moth	<u>4,000</u>
All defoliators	<u><u>229,760</u></u>

Sucking insects:	
Balsam woolly aphid	159,360
Spruce aphid	26,080
Pine needle scale	7,360
All sucking insects	192,800
Bark beetles:	
Douglas-fir beetle	324,840
Western pine beetle	294,300
Mountain pine beetle	265,420
Oregon pine ips	63,240
Fir engraver	34,160
Silver fir beetles	33,120
Engelmann spruce beetle	8,320
Douglas-fir engraver	2,400
All bark beetles	1,025,800
All insects	1,448,360

There were no large-scale direct-control projects in the region. Sanitation-salvage logging for western pine beetle control was increased on areas where the epidemic trend was up, and the program of importing insect predators to control the balsam woolly aphid was expanded for the third successive year.

Chance discovery of the European pine shoot moth on red pine at Bellevue, Wash., added another destructive foreign insect to the list of forest pests in the Pacific Coast States. We are cooperating in an effort sponsored by the Northwest Forest Pest Action Council to determine the distribution of the insect and to assess the possibility of eradicating it. So far it has been found in five ornamental tree nurseries in the Puget Sound area.

Epidemic infestations of the spruce budworm totaled 209,280 acres, the lowest amount since records were begun in 1947. An egg survey in August revealed the budworm population trend to be downward on all areas except in the Warner Mountains of southern Oregon, where it is upward. Even there, signs of increasing effectiveness of natural control are developing. No spraying is planned for 1960.

Damage by the balsam woolly aphid decreased for the second successive year. Aphid populations increased until fall; then unusually damp, cool weather--especially on high-elevation areas--slowed development of the second generation of the aphid and probably caused a considerable

reduction in the overwintering population. Infestations spread little beyond the limits previously recorded.



The extensive outbreak of the Douglas-fir beetle in southern Oregon that began in 1957 subsided due to natural causes. However, blowdown that occurred in southern Washington in the winter of 1958-59 was heavily attacked by the Douglas-fir beetle. In the spring of 1960, the beetle is expected to emerge and kill green timber extensively on areas where the down timber cannot be salvaged before then. A special survey (left) substantiated the impression that shaded windthrow produces heaviest broods, hence should be salvaged first in efforts to achieve control.

Tree killing by the western pine beetle increased in total amount for the third consecutive year, but varied locally, increasing on some areas and decreasing on others. The only serious outbreak was in southern Washington. In general, sanitation-salvage logging is keeping damage by the pine beetle within economically tolerable limits.

The mountain pine beetle continued epidemic in pole-sized ponderosa pine in various parts of the region. Because of the potential destructiveness of this insect, a two-stage experimental control project is planned for the Fremont National Forest. The first stage, to be undertaken in the spring of 1960, will consist of spraying infested trees with ethylene dibromide. The second, to be applied later, will involve thinning to improve tree vigor in the affected stands.

RESEARCH PROJECTS

Spruce Budworm

Emphasis this year was placed on determining the effects of spraying upon the budworm, its parasites, and associated defoliators. Long-term effects were determined from trend plots established after spray operations in 1949 and 1950; short-term effects, from intensive studies on an area sprayed in 1958. On unsprayed areas, we made studies to compare

larval populations and resulting damage on white fir and Douglas-fir; also, we continued studies on predators of hibernating larvae.

In 1959, 9 to 10 years after spraying, spruce budworm populations were very low and generally similar to what they were immediately after spraying. A mild upsurge occurred from 1954 through 1957, but a sharp downward trend occurred in 1958 and 1959. Parasitism of small larvae was high the year after spraying; subsequently it fluctuated considerably, but generally declined to lower levels. The larch bud moth was easily the most numerous defoliator during the 9 years of observations, except in two subalpine fir plots where black-headed budworm infestations occurred during 1958 and 1959.

Intensive studies on an area sprayed in 1958 explained some of the immediate effects of spraying. The degree of budworm control measured soon after spraying gives only a temporary index of control success; the long-term effectiveness of control is determined by the effects of spraying upon budworm parasites and associated insects. We drew the following conclusions:

1. Local differences in numbers of budworm surviving the spraying are still evident in spring, a year later. Subsequently, natural control factors--particularly parasites--tend to reduce these differences by exerting greater effect where budworm numbers are higher.
2. Favorable survival of the parasites that attack immature budworm larvae is reflected in higher parasitism by these species a year after spraying.
3. Poor survival of the parasites that attack full-grown larvae is overcome as early as a year after spraying, apparently because the parasites build up on an alternate host. In addition, parasites that are normally of minor importance and that are little affected by the spraying assume a major role in reducing budworm populations.
4. Parasites of budworm pupae show good survival immediately after spraying and increase in effectiveness the following year.
5. Some associated defoliators increase after spraying, while others decrease. Griselda radicana (Wlshm.) and Argyrotaenia dorsalana (Dyar), both of which cause minor economic damage, increased moderately. The larch bud moth, which occasionally causes noticeable damage decreased slightly. The combination of

these three species could result in continued damage to trees after spraying.

On unsprayed areas, a comparison of damage on white fir and Douglas-fir was concerned with defoliation of current needle growth and incidence of bud killing. Attempts were made to relate larval populations attacking opening buds to these indications of damage. A direct correlation between number of larvae and percentage of defoliation was obtained for 10 Douglas-fir trees, but not for 10 white fir trees. Number of larvae and percentage of buds killed were not correlated for either tree species. Although no statistical comparison was possible, white fir suffered heavier defoliation and greater bud killing than Douglas-fir with similar larval populations. Larval survival between the bud-attack period and pupation was higher on white fir.

We continued to study natural control of spruce budworm by predation during the hibernating period. Laboratory tests indicated that the larvae of a snake fly and a clerid beetle are effective predators. These predators caged with host larvae in their hibernating web have been observed killing as many as five larvae a week for a short time during early fall. Their effectiveness under natural conditions has not yet been established, but it is believed likely that they may be a considerable factor in natural control.

Pandora Moth

Because of the potential destructiveness of this large insect, the infestation discovered in 1958 on ponderosa pine near Sisters, Oreg., was watched carefully. Larvae suffered such heavy mortality that scarcely any defoliation occurred in 1959. The major reduction in larval populations took place during the winter; in spring two species of parasitic flies took a small but significant toll of the population. Less than 1 percent of the initial population survived until the first of June, at which time pupation was beginning.

Pupae placed in the soil were heavily preyed upon during summer and fall by small mammals. The predators removed pupae both by tunneling along beneath the litter and by excavating from above. By November only a few of the pupae remained.

It is evident that the 1960 generation of moths will not seriously threaten the pine on the infested area.

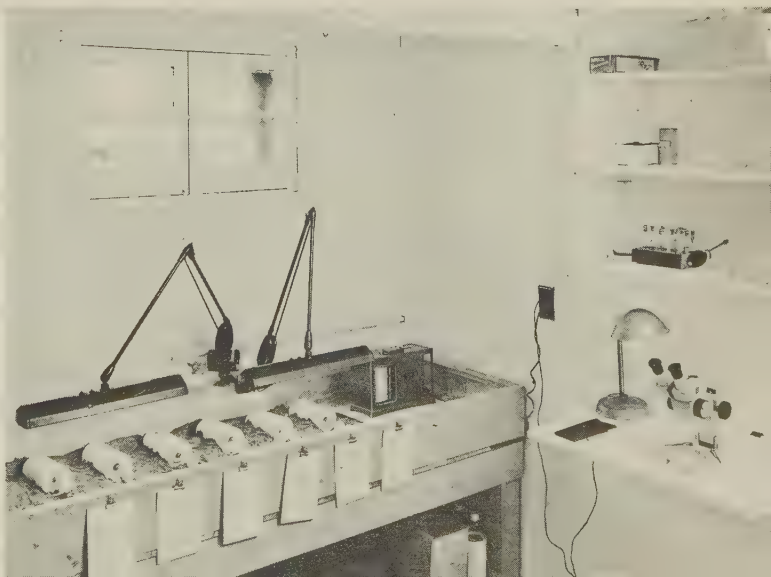
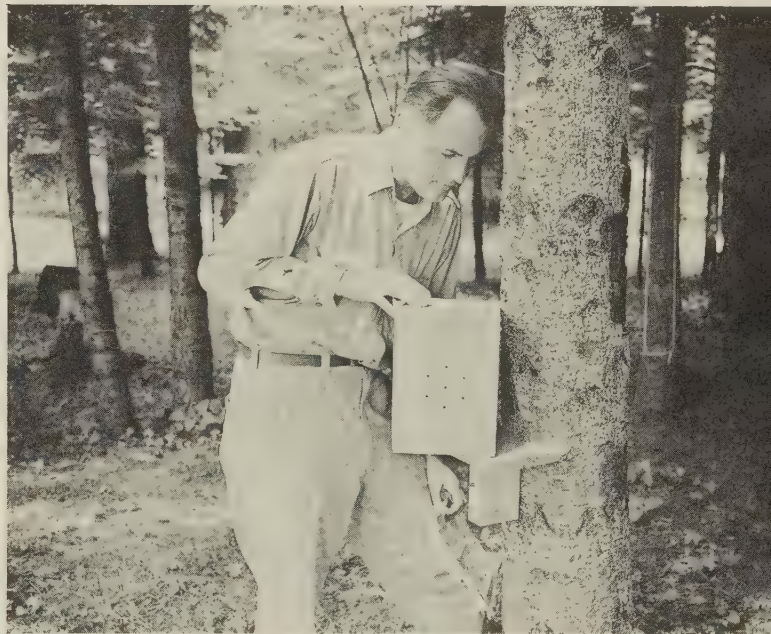
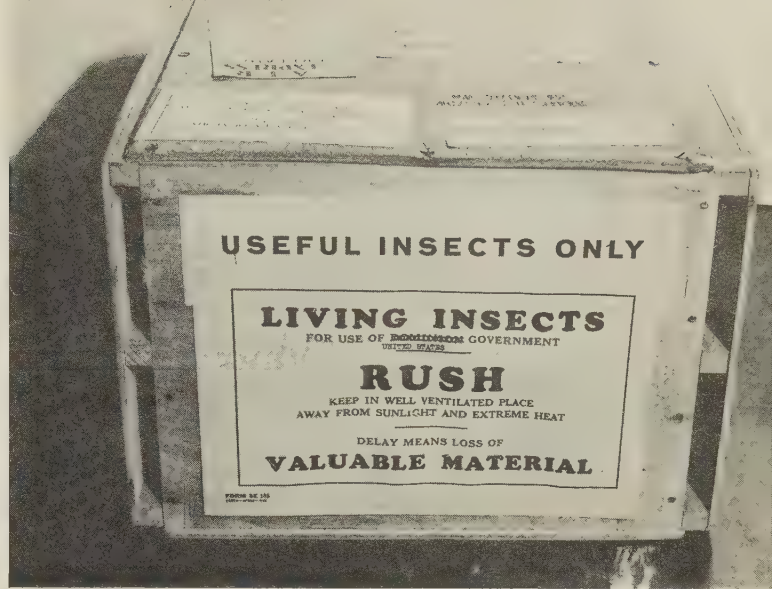
Balsam Woolly Aphid

The program that was started in 1957 to import foreign insect predators of the aphid was stepped up in 1959. From May to October, more

than 38,000 individual insects representing 13 species were imported and colonized in western Oregon and Washington. Eight of the species were released for the first time in the Pacific Northwest.

Predators were obtained from Australia, Czechoslovakia, India, Pakistan, and Germany through the cooperation of the Canadian Department of Agriculture. One foreign predator that has become established in eastern Canada and the Northeastern States was collected in Maine and supplied by entomologists of the Northeastern Forest Experiment Station, U.S. Forest Service. The predators are received in special containers (upper right) and either released directly from the container (center right) or reared in the laboratory (lower right) and then taken to the field.

So far, a fly (*Aphidoletes thompsoni* Möhn) and a beetle (*Laricobius erichsonii* (Rosenh.)) are the best established and most effective of the introduced predators. They have effectively reduced the aphid population on some trees, but their ability to control the aphid over wide areas will not be known for several years. Two other introduced predators are at least temporarily established.



Six of the foreign predators received this year arrived in late September and early October--too late for them to propagate or show other signs of establishment before winter.

Thirteen species of native insects and mites have been found feeding on the balsam woolly aphid. The most important of these are four species of hover flies and one species of brown lacewing. All the native predators provide some degree of control. However, they are seldom of much significance because they are usually not abundant nor are they always present during the same time of the season as the aphids.

The nature and trend of balsam woolly aphid infestations in subalpine fir stands is the subject of a study begun on the Willamette National Forest in Oregon. Findings to date indicate that, among true firs of the Northwest, subalpine fir is by far the most susceptible to attack and damage by the aphid. Pacific silver fir and grand fir are next in susceptibility.

Douglas-fir Beetle

A cooperative study with Weyerhaeuser Co.'s Forestry Research Center revealed that the hazard of Douglas-fir beetle outbreaks is more likely to be acute with some kinds of windthrow than with others. Interpretation of data collected from the St. Helens, Vail, and McDonald Tree Farms in western Washington led to the following conclusions:

1. Second-growth Douglas-fir (less than 160 years old) exposed to direct sunlight produces only about a third as many beetles per parent gallery as shaded second growth. In addition, galleries are less than half as numerous in exposed trees.
2. Exposed old-growth Douglas-fir produces nearly as many beetles as shaded old growth--apparently due to the thick bark, which provides insulation and prevents rapid drying of the cambium.
3. In scheduling salvage of large areas of blowdown that cannot all be logged promptly, the following priorities should prevail:
 - A. Second growth, shaded.
 - B. Old growth, shaded.
 - C. Old growth, exposed.
 - D. Second growth, exposed.

Cone and Seed Insects

We provided technical assistance to national-forest resource management on an administrative study to determine whether spraying would reduce insect damage to Douglas-fir cones. The study was made on three areas on the Olympic National Forest, using techniques based on recent research findings of Weyerhaeuser Co. On two of the plots, seed yield from cone samples was increased by 21.4 and 36.4 percent, respectively. On the third plot there was no significant difference between the yield of sprayed trees and that of comparable unsprayed check trees.

Treatment consisted of two applications of insecticide--one of Sevin and one of DDT. The Sevin was applied as a 0.25 percent water-emulsion spray at the rate of 4 gallons per tree, to control the Douglas-fir cone midge (Contarinia oregonensis). Spraying was done in late April, when the conelets were open to receive pollen--the time when the midge lays its eggs. The DDT was applied about 2 weeks later at the same strength and formulation as the Sevin. This application was directed at the Douglas-fir cone moth, Barbara colfaxiana, which bores into the closed and developing cone.

Results of this empirical study are not regarded as conclusive, for several reasons. For one, the Douglas-fir cone crop was the heaviest in many years, diluting the insect population to the extent that little damage was caused, even on unsprayed trees. Secondly, the degree of control between plots varied widely--for unknown reasons. Formalized studies are needed before positive recommendations can be made. However, the findings in 1959 were encouraging and offer hope that practical methods for controlling cone and seed insects of Douglas-fir can be developed through adequate experimentation.

Sitka-spruce Weevil

Cooperative studies on two areas of Crown Zellerbach Corp.'s Clatsop Tree Farm in northwestern Oregon continued to show that (1) damage declines as Sitka spruce reaches 25 to 30 years old and (2) attacks by the weevil are more frequent and more severe on spruce growing inland.

In a 30-year-old spruce plantation some 15 miles from the coast in the Youngs River drainage, only 5 to 10 percent of the trees have been weeviled annually the past 3 years. In comparison, 15 to 35 percent of the trees were weeviled each year from 1950 to 1956.

On the second area, located at Tillamook Head on the coast, weevil-ing continued to be light in the 10- to 15-year-old spruce. Less than 5 percent of the trees have been weeviled annually for the past 7 years. Findings from these studies suggest that forest managers can expect less weevil damage to spruce grown in its optimum range near the coast than

to spruce grown on drier inland sites, which are perhaps better suited to Douglas-fir or other species.

PLANS FOR 1960

Surveys. --Continue the regional cooperative survey on about the same scale as in recent years, and conduct special surveys as needed. Increase emphasis upon biological evaluation by putting accumulated research findings into practice.

Technical supervision of control. --Provide assistance as required. Give specific attention to experimental control of mountain pine beetle in ponderosa pine, and continue efforts to effect biological control of the balsam woolly aphid.

Insect diseases. --Staff and activate a program of research on diseases of forest insects.

Spruce budworm. --Reorganize trend studies so as to improve methods and reliability in measuring population trend. Conclude studies, begun in 1958, of the effects of spraying upon the budworm, its parasites, and associated insects. Begin studies on the effects of natural control factors outside the major epidemic area, and continue studies of factors affecting damage.

Balsam woolly aphid. --Continue importation and evaluation of foreign predators, and attempt to propagate and redistribute foreign species now established. Expand studies of the effects of the aphid upon its host trees in the Northwest.

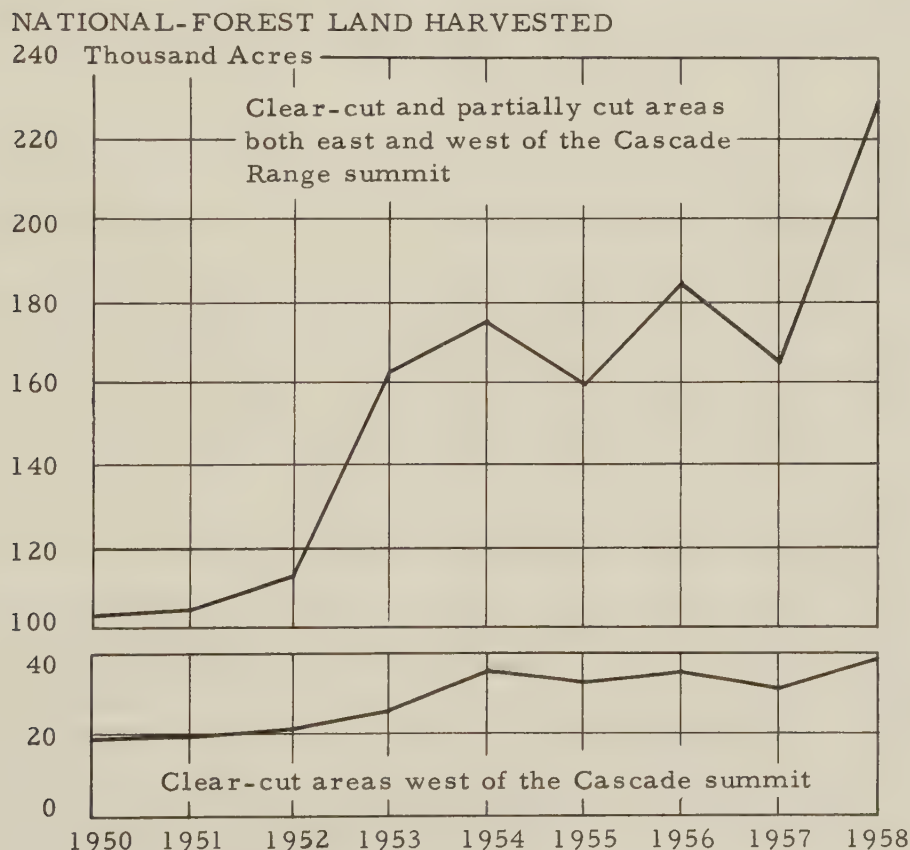
Douglas-fir beetle. --Continue to follow trends of mortality on long-term study plots, and assess the relation between blowdown and subsequent beetle kill. Make deterioration analyses of beetle-killed trees.

Insects affecting regeneration. --Continue studies of the Sitka-spruce weevil, including determination of susceptibility of native, exotic, and hybrid spruces. Continue exploratory studies of the biology and control of insects that damage coniferous tree seed.

Forest Fire Research

Fire continues to be a major problem to forest managers in the Pacific Northwest. About \$13 million is spent annually by Federal, State, and private forestry agencies in Oregon and Washington to protect forests from fire. Damage from fire adds about \$6 million to the annual bill.

Fire is important in the Northwest not only because of dry summers and occasional periods of extreme fire weather, but also because of unusually heavy fuels. Rapid harvesting of mature forests has greatly increased fire danger in the region by increasing both the amount of dead fuel near the ground and its exposure to wind and sun. On national-forest land in Oregon and Washington, the rate of all cutting--in terms of area--has doubled in the 8-year period 1950-58 (below).



Fuel quantities on most of the forested and cutover lands west of the summit of the Cascade Range exceed those on nearly all other forest areas of the United States. A crown fire in a mature stand can consume about 100 tons of fuel per acre. In dry weather, an average wildfire in logging slash could be expected to burn 115 tons of material per acre. The intense heat from such great quantities of burning fuel defies presently known methods of direct extinction. New methods of fire fighting need to be perfected for the special conditions found in this region.

Not always an enemy, fire is also a forest management tool. Properly used, it prepares the site for growing a new crop of timber, particularly following logging of decadent old-growth stands. Thus, fire is used to remove some 200,000 acres of heavy slash annually in the two States. Improved burning techniques are needed, however, to permit safe use of fire to accomplish any of a broad spectrum of objectives.

Effective prevention, suppression, and use of fire require detailed prediction of wind, atmospheric moisture, and temperature. In our mountainous forest areas, the broken terrain exerts a complex influence on the weather, causing great variation within short distances and within short time intervals. Procedures are needed for accurate prediction of this local weather, which is now largely estimated through local interpretation.

As forest values increase and forestry is practiced more intensively, it is essential that knowledge of fire keep apace. This requires more detailed techniques for predicting fire behavior, more effective fire prevention, more reliable procedures for evaluating fire damage and forest protection benefits, and better techniques for classifying fuels in terms of their behavior characteristics. The number of top-priority fire problems far exceeds the capacity of our two-man fire research staff. Some work is being done, however, in the areas of fire-danger rating, fire weather, fire effects, and slash and wildfire behavior.

FIRE-DANGER RATING

Effect of Weathering on Moisture-Indicator Stick Accuracy

Fuel-moisture-indicator sticks lose weight as a result of weathering, with amount of loss varying by climatic zone. In some zones the loss is great enough to require correction if fire-danger rating is to be accurate. We found that stick weight losses increased in approximate proportion to length of exposure during the fire season. Average monthly losses for major areas, expressed as a percentage of original dry weight of 100 grams, were as follows: Coastal strip (Oregon only), 0.67; west slope of Cascade Range, 0.45; east slope of Cascade Range and Fremont National Forest, 0.35; Ochoco Mountains and northeastern Oregon, 0.27.

Correction of the observed fuel-moisture readings is recommended before comparing readings made at different times at one station, or at the same time at stations in different climatic zones. For example, 0.9 should be added to an observation made at a west-slope Cascade station before comparing it with an observation made 2 months earlier at the same station. This study also emphasizes the importance of simultaneous exposure of moisture-indicator sticks at all stations at the beginning of the fire season.

Prediction Aids for Fuel Moisture

Prediction of fire danger usually requires a forecast of the moisture content of fuel-moisture-indicator sticks. During fair summer weather, afternoon fuel moisture is closely correlated with afternoon relative humidity. Using this relationship, we devised an aid for predicting tomorrow's 4:30 p.m. fuel moisture. The user need only know today's 4:30 p.m. fuel moisture and the relative humidity predicted for 4:30 p.m. tomorrow. This aid may be used for any standard fire-danger station in Oregon and Washington.

We also devised aids for predicting afternoon fuel moisture from the observed morning fuel moisture and predicted relative humidity. Separate aids are used for valley and peak stations to take into account differences in nighttime recovery of moisture from the air, which is greater at valley stations.

Use of these aids with accurate relative-humidity forecasts can increase average accuracy of fuel-moisture estimates by 10 to 15 percentage points.

Adjustment of Relative Humidity and Temperature for Differences in Elevation

Relative humidity is of great importance in forest fire control. Changes in the moisture content of small-diameter, flashy fuels and in forest flammability are closely related to changes in humidity. Correct prediction of humidity is therefore essential to prediction of fuel moisture and ultimately to prediction of fire danger.

Prediction of relative humidity in mountainous terrain is complicated by temperature change with elevation and by differences in moisture at different elevations. Within an air stratum that is vertically mixed, however, moisture is constant and temperature varies with elevation at a constant rate. We found that this relationship could be expressed on a simple chart by means of which humidity known for any point within a mixed layer may be readily adjusted for any other elevation within that layer.

During the afternoons of sunny summer days, mixed layers often extend upward several thousand feet from the earth's surface. A second chart permits identification of a mixed layer by comparison of temperature observations at stations of different elevation. These two charts will permit more intensive use of humidity and temperature predictions for mountainous areas.

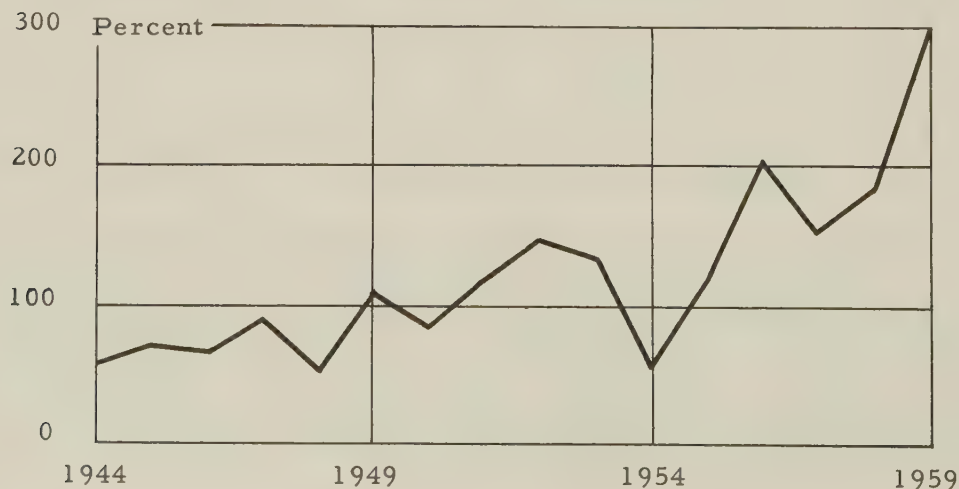
1959 FIRE WEATHER IN THE DOUGLAS-FIR REGION

Nonuniformity was the primary characteristic of the April 1–October 31 fire season, according to season-weather indexes that we calculated. For western Washington, the season was the least severe since 1956, with spring and summer slightly below normal severity and fall much less severe than normal. In western Oregon, the season ranged from normal during spring and fall to one of the most severe summer periods of record. Greatest departures above normal occurred in southern Oregon. Summer lightning storms were less frequent than usual on all west-side forests in both States.

For the first time in this region, we determined fire-season severity in terms of the fire occurrence that might have been expected with the observed weather conditions. This computed fire occurrence was obtained after the close of the season by means of regression equations that express, for recent years, the relation between severity of the season's weather and the occurrence of fires.

In comparison with number of fires expected, actual occurrence for 1959 showed a continuing rising trend in number of man-caused fires on the national forests of western Washington (below). On State and

ACTUAL NUMBER OF MAN-CAUSED FIRES
AS A PERCENTAGE OF NUMBER EXPECTED



privately protected lands in western Washington, there appears to be a continuing swing, starting in 1957, toward fewer than expected man-caused fires. In this same area there is also a trend toward a smaller proportion of fires becoming larger than 1/4 acre. No other trends were indicated for these half-State ownership groups in either western Oregon or western Washington.

We believe this technique will prove very helpful in pointing out changing fire-control problems in the Pacific Northwest.

PLANS FOR 1960

No major change in scope and direction of fire research investigations is anticipated for 1960. Fire weather and fire behavior will continue to receive greatest attention. An increasing amount of time will be spent in analysis of fire research needs in Oregon and Washington. Some specific objectives are:

1. Analyze slash-fire and wildfire behavior records from many case studies.
2. Revise the analysis of fire problems of this region and prepare a proposed program of studies.
3. Cooperate with national-forest administration in a project to develop guidelines for improving fire-weather services.

Forest Economics Research

Forest Survey's reinventory of the region continues to be the backbone of our economics research activities. This will be the case in the future, even though production economics and marketing studies are increasing in number and effectiveness. The emphasis in economic studies has been and will be along two lines: (1) to make more analysis and interpretation of the resource facts collected by Forest Survey and (2) to conduct studies that will be helpful to those who must manage the resource so that the benefits of values protected and goods and services produced will exceed their cost.

The efficiency of Forest Survey operations is continually being improved. Electronic computers not only provide greater speed but make it possible to incorporate refinements that would be impossible to handle by former compilation methods. Plans include increased use of aerial photos and research in basic forest-measurement problems.

PRODUCTION ECONOMICS AND MARKETING

Timber Trends in the Douglas-fir Subregion

In a study of timber trends in western Oregon and western Washington, begun in 1958, we are examining the timber supply outlook for different ownership classes of private and public timberland. Purpose of the study is to outline the longrun problems in timber supply and to furnish a basis for private and public forest policies.

Attention is centered on three principal influences affecting future levels of timber output: the amount of land devoted to timber production, the amount of growing stock, and the intensity of forest management. Prospective levels of growing stock and intensities of management are developed for the major landowner classes, taking account of the guiding rates of return typifying the timber management goals of each class.

Major issues include:

1. Rate of development of the timber economy during transition from a predominantly old-growth forest structure to one with a more balanced age-class distribution.
2. Alternative product objectives--small logs vs. large logs; short rotations vs. long rotations.

3. Trends in management practices in all landowner classes.
4. Relation of public to private timber management during the transition period.
5. Shifts in land use and shifts in ownership status of privately held lands.

Calculation of a longrun growth potential for the Douglas-fir sub-region is involved, with estimates of prospective yields and allowable cuts during the transition period.

The data has been analyzed, and a manuscript is being prepared.

Economic Significance of Mortality in Old-Growth Douglas-fir

The relation of mortality to the conditions in old-growth Douglas-fir stands is clarified by the following tabular analysis:

	<u>Additions</u>	<u>Subtractions</u>
Live growing stock	1. Gross growth	1. Cutting operations 2. Catastrophic losses 3. Enphytotic mortality 4. Decay in live trees
Accumulated dead material	1. Enphytotic mortality 2. Catastrophic mortality	1. Salvage during cutting operations 2. Decay in dead trees 3. Special salvage operations

On the left are the two sources of timber products in old-growth stands. The two columns on the right indicate changes that occur in the volume of live growing stock and the volume of accumulated dead material. In the third column, two types of subtraction are shown: (1) those which produce forest products--regular cutting and salvage--and (2) those which are unplanned, unintentional, and wasteful, resulting in physical loss of forest products. This second type may require further action on the part of old-growth owners and managers.

At present, very little can be done toward preventing decay in live old-growth trees. Some control over catastrophic losses can be obtained by fire prevention and insect and disease control. Also, catastrophic

mortality can be salvaged promptly whenever possible and thus reduce total loss from this source.

Enphytotic mortality is that which occurs more or less normally each year in all forests. It does not greatly alarm foresters, and is generally expected to be heavy in overmature forests. As the tabulation indicates, enphytotic mortality represents a change from live sound material to dead sound material. The amount of decay occurring in dead trees is primarily a function of the volume of dead material. Therefore, if the salvable part of accumulated dead material could be removed from existing old-growth stands, such as in leave settings between clearcuts, then decay occurring in dead trees could be greatly reduced. Furthermore, subsequent removal of merchantable enphytotic mortality could accomplish the dual purpose of salvaging one type of loss from the live-timber inventory and preventing, or at least reducing, the buildup of dead material and the decay which would take place in it.

We analyzed the economic significance of mortality in old-growth Douglas-fir stands and estimate that enphytotic mortality occurs at the rate of 359 net merchantable board feet per acre per year. With approximately 3 million acres of old-growth Douglas-fir remaining in the Douglas-fir subregion of the Pacific Northwest, some 1,077 million board feet of timber is being subtracted annually from the live timber inventory and added to the accumulated dead material. We also estimate that 23 percent of old-growth Douglas-fir stands lie within a quarter mile of an existing road, indicating that a fair proportion of both accumulated dead material and enphytotic mortality is readily accessible today. Reduction of mortality losses in the remainder of these stands would require building a road system in advance of final harvest.

A manuscript has been prepared for publication as a Station research paper, setting forth the findings of this study and discussing (1) economic considerations relating to salvage logging and (2) criteria determining priorities in choice of stands for salvage.

Harvesting Minor Forest Products in the Pacific Northwest

Commercial harvesting of minor forest products is increasing in the Pacific Northwest. They can often be harvested as byproducts on timberlands used primarily for log and pulpwood production, providing employment and income opportunities for several hundred persons in rural areas.

Christmas trees, decorative greens, and forest seed cones are important minor products in many areas. Although most Christmas trees still come from essentially wild forests, more and more are being harvested from cultured natural stands or from plantations. Organized

channels have developed for collection, packaging, and marketing of decorative greens. Reforestation programs have increased the demand for seed of important timber trees.

Other minor products include cascara bark, charcoal wood, fuelwood, medicinal herbs, ornamental plants, specialty woods, and split cedar products.

Economic Value of Pacific Northwest Forest Industries

Contributions of forest industries to the Pacific Northwest economy have been compiled from selected published sources to provide a comprehensive summary for regional use. In addition to logging, the forest industries include manufacture of lumber, plywood, furniture, poles and piling, composition board, pulp, paper, paperboard, and other wood products.

In 1958, forest industry employment constituted 58 percent of all manufacturing employment in Oregon, and 28 percent of manufacturing employment in Washington. In several counties, forest industry employment is greater than that of any other industry class, including agriculture. Table 6 presents a digest of employment data, value added by manufacture, and value of shipments for the year 1957.

Table 6.--Economic values produced in Pacific Northwest forest industries per unit of log production, 1957

Area	Employment	Wages and salaries	Value added by manufacture	Value of shipments
	Man-years per million bd.ft.	-- Dollars per thousand board feet --		
Oregon	10.6	50.71	79.90	132.68
Washington	16.2	78.05	147.02	205.07
Pacific Northwest	12.6	60.24	103.31	157.93

Small Forest-Land Ownership in the Douglas-fir Subregion

We have begun an analysis of the small forest-land ownership situation in the Douglas-fir subregion. Our objective is twofold: (1) to assemble and coordinate all relevant data from previous research in order to achieve a clearer understanding of the problems associated with small ownerships, and (2) to define those aspects of the problem deserving

further research. The analysis will result in specific studies designed to assist landowners in recognizing the potential of their forest land and profiting from improved management.

Economic Availability of Unused Wood Materials

Since World War II there has been a dramatic increase in wood utilization in the Douglas-fir subregion. Logging residues have been reduced by closer utilization and by prelogging or relogging material formerly damaged or left in the main operation. The amount of unused mill residues has been greatly reduced through development of smaller debarkers and chippers and expansion of chip markets in the pulp, paper, and composition-board industries. Use of native hardwoods and upper-elevation conifers is gradually increasing. Considerable volumes in all these classes of raw material, however, remain unused.

We are exploring the economic availability of currently unused wood material in Lane County, Oreg. This study has three main objectives:

1. To develop criteria that will serve as a measure of economic availability of wood residues.
2. To provide guides to profitable residue use, taking into account the type of material, landownership, method of sale, type of mill, and end products for which the material is suited.
3. To suggest some adjustments in forest management practices and industrial organization that would contribute to improved utilization.

Industrial Capacity in the Douglas-fir Subregion

Industrial capacity is a little-studied aspect of the economics of forest production. Excess capacity exists in the industries dependent upon forest resources at different times and for various reasons. The amount of such excess capacity that can be expected in a healthy economy and its impact upon the industry and the resource is not clearly understood. We have begun a project to estimate industrial capacity for the Douglas-fir subregion and relate it historically to actual production of logs and consumption of pulp, plywood, and lumber.

Capital Budgeting for Forest Management

We also have started to develop general guides for forest management planning based on the economic view that forest management is primarily a problem of capital management. Basic concepts, principles, and special problems in capital budgeting for forest businesses are being studied, and case examples are being developed.

FOREST SURVEY

Forest Inventory

The reinventory of the region's forests by Forest Survey and co-operating agencies continued in 1959.

An intensive forest inventory of the Colville Indian Reservation in northeastern Washington, begun in 1958, was completed and a statistical report prepared for the Bureau of Indian Affairs. A forest type map showing understory and overstory stands at a scale of 4 inches to the mile was also prepared.

Close cooperation between Forest Survey and national-forest resource management continued, with the joint inventory of approximately 1 million acres of commercial forest land in two national-forest working circles. In addition, six working circles were inventoried to Forest Survey standards by national-forest crews. These working circles lie in several counties in Oregon, and the inventory data for them will be incorporated with similar data from subsequent Forest Survey inventories for the other ownership classes in the area.

In Washington, field work was completed for the reinventory of forest lands in Okanogan, Pierce, Kitsap, and Island Counties. Also, a substantial start was made in King, Jefferson, and Chelan Counties.

Altogether, a total of some 5 million acres of forest land was covered in the field this past year in Oregon and Washington by inventories to Forest Survey standards.

Results of inventories of forests in Skagit and Whatcom Counties, Wash., were analyzed and published. Compilation of data for Union, Umatilla, and Wallowa Counties in Oregon has been completed and reports are being prepared.

The Eastern Oregon Forest Economy

During 1959, we cooperated with the Census Bureau in a survey of forest industries in eastern Oregon. Preliminary analysis of data from

this survey has already revealed many interesting facts, such as the following:

<u>Sawmill size by capacity per 8-hour shift (M bd. ft.)</u>	<u>Percentage of total No. of mills (Percent)</u>	<u>Percentage of total log consumption (Percent)</u>
0 - 39	31	4
40 - 79	43	40
80 - 120	19	29
120+	<u>7</u>	<u>27</u>
	100	100

In 1958, field work for the second reinventory was completed in the last county in eastern Oregon, and forest resource data for all eastern Oregon counties is now being compiled. Since eastern Oregon is an easily defined unit--geographic, political, and economic--available forest resource and forest industry facts will be combined and interpreted in some detail for this half-State area.

Logging Utilization Factors

Analysis of the results of a 1958 logging study in eastern Oregon supplied data useful in solving several difficult inventory problems. The study provided (1) an estimate of the ratio of inventory measurements to forest products measurements, (2) information on current tree-utilization practices, and (3) estimates of logging damage and residue.

The most important result was the establishment of a board-foot volume relation between actual output measured as timber products and drain on the resource as measured to Forest Survey standards. This relationship permits us to estimate drain on forest inventory in eastern Oregon by multiplying log harvest by 0.972.

Another result was the relation between current utilization practices, as actually observed in the woods in 1958, and the standards used in Bruce and Girard's 1947 board-foot volume tables for 32-foot logs. On the average, trees less than 33 inches d.b.h. were not bucked into logs quite as high in the tree as the volume tables indicated, whereas trees larger than 33 inches were utilized more completely than Bruce and Girard anticipated. However, the differences in terms of volume are small--usually less than 1 percent.

Logging residues amounted to 4 percent of the cubic volume of sound wood in trees cut, with the equivalent of another 1.5 percent of this volume in smaller trees killed in logging but not cut.

Another item of interest from the study was the relation between stump d.i.b. and d.b.h. (outside bark). This relation can be used to estimate d.b.h. from stump measurements in trespass cases. The ratio of d.b.h. to stump d.i.b. for several species was found to be as follows:

Douglas-fir	1.025
White fir	1.023
Ponderosa pine	.992
Western larch	.977
Lodgepole pine	.947
Subalpine fir	.853
Engelmann spruce	.829

Data Processing Programs

During 1959 we completed three new electronic computer programs for use in forest inventories. These promise to have considerable value in several fields of research as well as in inventory work. The new programs were designed to complement current electronic programs for computing volume and growth.

Two of these programs, 650-12 and 650-13, compute Scribner board-foot volume for 16- or 32-foot scaling lengths from measurements of d.b.h., total height, and form class. The third program, 650-9, expresses the relation of volume to d.b.h. as a second-degree curve. These three programs are a part of our efforts to develop integrated electronic programs for faster and more accurate handling of forest inventory data. The 650-9 program has been developed with other needs in mind. It solves simultaneously several equations of relationship between two variables. These equations are:

$$\begin{array}{ll}
 y = bx & y = a+bx^2 \\
 y = bx \text{ (ratio estimate)} & y = a+bx+cx^2 \\
 y = bx^2 & y = a+bx+cx^2+dx^3 \\
 y = a+bx &
 \end{array}$$

Another development was the determination of weighting factors to be used in computing the relation between tree volume and d.b.h. in the Pacific Northwest. These weighting factors and their use are described in a Station research note.

PLANS FOR 1960

1. Complete the review draft of a report on the study of timber trends in the Douglas-fir subregion.
2. Complete analysis of small forest ownerships in the Douglas-fir subregion and begin studies as needed.

3. Prepare a report on industrial capacity in pulp, plywood, and lumber production for the Douglas-fir subregion.
4. Seek even greater reduction in the volume of unused wood material in Lane County, Oreg., by discovering and measuring factors that control the use of this material.
5. Cooperate with national-forest resource management to measure logging utilization on the Umpqua, Siskiyou, and Rogue River National Forests.
6. Probe further into the economics of salvaging mortality of all kinds in old-growth Douglas-fir.
7. Interpret the significance of the latest forest resource and forest industry facts for eastern Oregon.
8. Complete field work for reinventory of forest land in King, Clallam, Chelan, Jefferson, and San Juan Counties in northwestern Washington; and Lincoln, Whitman, Spokane, Stevens, Pend Oreille, and Ferry Counties in northeastern Washington.
9. Prepare statistical reports for Union and Umatilla Counties, Grant County, and Wallowa County, all in Oregon. Also for Asotin, Columbia, Garfield, and Walla Walla Counties; Okanogan County; and Pierce, Kitsap, and Island Counties; all in Washington.
10. Cooperate with forest industry, the U.S. Forest Products Laboratory, State agencies, and other Federal agencies in the collection of increment cores as the basis for determining specific gravity and, ultimately, strength of western softwoods.
11. Prepare a manuscript on capital budgeting in management of private forests.

Aerial Survey Techniques Research

Aerial survey techniques research is conducted jointly with national-forest administration. The purpose is to develop improved methods for making forest-land inventories, forest insect surveys, and timber management plan surveys. Principles developed should be applicable throughout the western regions of the United States.

FOREST INVENTORY AND MANAGEMENT SURVEYS

Work this year was concentrated on several studies involving the application of aerial photos to stand volume tables, estimation of forest sites, and unit-area control.

Aerial-Photo Volume Tables

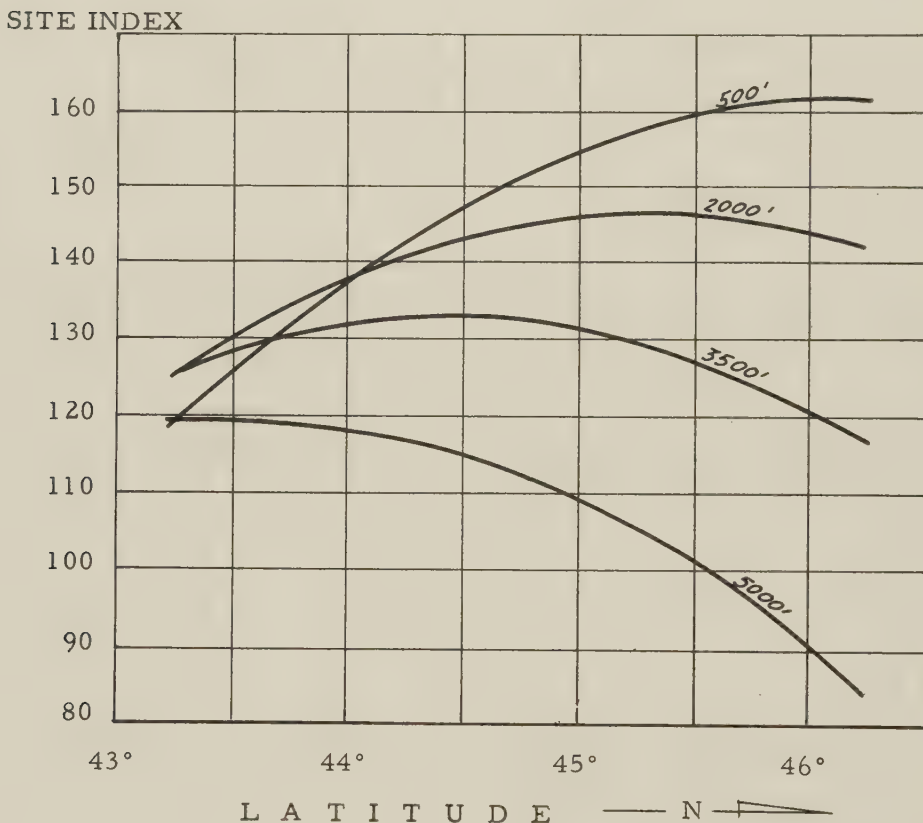
Interpretation has been completed on 366 photo-volume-table plots, and analysis is underway. Initial inspection of the data confirms previous experience that stand height and crown density are the best indicators of stand volume. Crown diameter seems to have little relation to stand volume, whereas site index does: for stands with same height and density, there is more volume on lower sites than on higher sites. This may turn out to be the key for applying universal volume tables to different areas. Electronic computers are being used to make a complete statistical analysis.

Forest Site

We have completed a study to test the feasibility of estimating Douglas-fir site index from aerial photos. About 800 observations from the western slope of the Oregon Cascades were used to determine what physiographic features, obtained from photos or topographic maps, were helpful in predicting site index. Analysis revealed that the following variables were significantly related to site index: elevation, latitude; topographic shape; a combination of aspect and slope; and depth of soil, crudely classified as either shallow or deep according to whether rock outcrops are visible on the photos.

Although each of the above variables was significant, combined they accounted for only 28 percent of the total variation in site index. The practical application of this method for obtaining site index information is somewhat marginal--that is, under average conditions a given amount of information costs about as much to get from the photos as it does on the ground. However, where field costs are higher than average this approach is likely to pay off.

An interesting result of this study is the interaction between latitude and elevation. As you go from south to north, site index increases for the lower elevations but decreases for the higher elevations (below).



The use of additional variables, particularly those of soil characteristics, might increase the variation accounted for and make the photographic approach much more efficient.

Unit Area Control

We have obtained preliminary results from a study to test the usefulness of aerial photos for identifying the various forest condition classes necessary in management of ponderosa pine by unit area control. Three photo scales, ranging from 1:12,000 to 1:5,000, were tested. All scales were found to be useful in obtaining the desired information. There appears to be no significant increase in interpretation accuracy as photo scale increases.

FOREST INSECT SURVEYS

Our major effort in this field during the past year has been aimed at completing existing studies and beginning a shift in emphasis from surveys of past damage to surveys reflecting current insect populations.

Engelmann Spruce Beetle

The possibilities of assessing mortality caused by the Engelmann spruce beetle were explored in cooperation with the Rocky Mountain Forest and Range Experiment Station. We studied large-scale color and camouflage-detection photos of an epidemic in Colorado but were unable to correctly identify the Engelmann spruce mortality. Our failure was apparently due to the erratic fading habit of the spruce plus confusion with mortality of other species. The photos are now being studied by interpreters at the Rocky Mountain Station to determine if their on-the-ground experience will enable them to do a better job.

Douglas-fir Beetle

Past studies on the use of aerial photos in forest insect surveys have been concerned with assessing damage or mortality caused by the previous generation of insects. A shift in emphasis towards using photos in evaluating current insect populations began with a small exploratory study in the late fall of 1958. At this time of year a proportion of the trees infested by the Douglas-fir beetle fade. Others stay green over winter and fade the following spring.

Although not all infested trees had faded, a good correlation was obtained between faded trees counted on large-scale late-fall color photos and actual infested trees counted on the ground. The results are encouraging enough to warrant further investigation.

COLOR FILMS

In order to keep up to date on available study materials, we compared two color films not previously tried by this Station (Anscochrome and Ektacolor) with color films used in the past (Ektachrome and

camouflage-detection). Superficial comparison indicates that Anscochrome possesses several desirable characteristics, including fine grain and exposure latitude, and should be further tested under controlled conditions. Ektacolor, although not as sharp as the other color films, also deserves further testing because the end product--a color print--is easier to use than the usual transparency.

PLANS FOR 1960

In the field of forest inventory and management surveys, we will complete current studies on aerial-photo volume tables, unit area control, two-story type mapping, and localized volume estimation. The possibility of improving photo recognition of forest sites by introducing new variables will be explored, and a start will be made on the development and testing of efficient methods for using aerial photos to improve Forest Survey area statistics.

Research needs in the field of Forest Survey and mensuration will be reviewed and a start made to expand techniques research into these fields.

In the field of forest insect surveys, we will continue work on reporting terminated studies. On new studies, emphasis will continue to shift towards using photos as a tool to improve surveys of current insect populations.

1959 Publications by staff members and cooperators

FOREST ECONOMICS

Adams, Thomas C.

Marketing of farm forest products in thirteen western Oregon counties. Oreg. Agr. Expt. Sta. Station Bul. 567, 26 pp., illus.

(A marketing study of timber sales experience of small forest owners. Key factors favorably influencing prices paid to forest owners include: (1) previous experience in timber sales, (2) competitive bids for stumpage, and (3) use of technical management and marketing services of farm foresters and consulting foresters. Sales experience was more frequently satisfactory where the landowner participated in the logging or where there was frequent inspection and supervision of the sale.)

Gedney, Donald R., and Johnson, Floyd A.

Weighting factors for computing the relation between tree volume and d.b.h. in the Pacific Northwest. Pac. NW. Forest & Range Expt. Sta. Res. Note 174, 5 pp.

(In developing a least-squares curve relating tree volume to d.b.h., it is assumed that variance in volume is the same for all diameter classes. However, since variance in volume usually increases with diameter, it is necessary to weight each observation by the inverse of variance for its diameter class. A set of inverse-of-variance weighting factors is given for Pacific Northwest species.)

_____, Johnson, Floyd A., and Hicks, Vernon E.

Some estimates of growth and mortality from the Malheur National Forest in eastern Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 166, 7 pp., illus.

(The average annual net growth of all forest types was shown to be 94 board feet per acre. Ponderosa pine type grew 78 board feet per acre, and "other" types--including Douglas-fir, white fir, and western larch--grew 108 board feet per acre per year. Curves of growth by diameter class indicate that ponderosa pine, in terms of individual trees, has the greatest potential for growth.)

MacLean, Colin D., and Hightree, Paul E.

Forest statistics for Skagit and Whatcom Counties, Washington. Pac. NW. Forest & Range Expt. Sta. Forest Survey Rpt. 133, 47 pp., illus.

(A statistical report presenting results of a recent reinventory of forests in the two counties. Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.)

McClay, T. A.

Seasonal fluctuations in ponderosa pine lumber prices. Jour. Forestry 57: 644-647, illus.

(A graphic and statistical analysis of Western Pine Association average index prices for ponderosa pine lumber. Covering the 20-year period from 1936 through 1955, the analysis reveals a significant upward trend in prices but does not uncover any consistent seasonal variation. The absence of such variation is attributed to sporadic behavior of price-influencing elements during the 20-year period.)

McMahon, R. O.

A new technique for estimating forest-land areas by ownership class. Agr. Econ. Res. 11(2 and 3): 81-88.

(Presents a new technique for making extensive surveys of forest-land ownership patterns. It uses a random point-sample design and supplements the traditional line transect and area sampling methods commonly used in forest ownership surveys. It has special advantages where basic information is available to confine selection of sample points to the population being studied.)

FOREST MANAGEMENT

Berntsen, Carl M.

A look at red alder--pure, and in mixture with conifers. Soc. Amer. Foresters Proc. 1958: 157-158, illus.

(A substantial increase in cubic-foot yield was noted when mixed alder-conifer stands were converted to one or the other of their composition components: 14 percent increase when converted to pure alder, and 48 percent when converted to pure conifer.)

Carow, John

Yarding and loading costs for salvaging in old-growth Douglas-fir with a mobile high-lead yarder. Pac. NW. Forest & Range Expt. Sta. Res. Paper 32, 26 pp., illus.

(Describes the use of a mobile high-lead yarder to salvage dead and down timber in old-growth Douglas-fir stands, and presents results of a time and production study of the yarding operation. A formula is given for evaluating the several variables involved in planning an efficient salvage operation.)

Gratkowski, H.

Effects of herbicides on some important brush species in southwestern Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Paper 31, 33 pp., illus.

(Thirteen of the most abundant brush species on forest lands showed different degrees of susceptibility to various concentrations and combinations of six herbicides. Low volatile esters of 2,4-D and 2,4,5-T proved most effective of the herbicides tested.)

Hallin, William E.

Release of sugar pine seedlings and saplings by harvest cutting. Pac. NW. Forest & Range Expt. Sta. Res. Note 179, 3 pp., illus.

(Understory sugar pine seedlings will respond with increased height growth after removal of an overstory, but additional study is needed to determine economic advantage or disadvantage over starting fresh with planted sugar pine.)

Krueger, Kenneth W.

Diameter growth of plantation-grown Douglas-fir trees under varying degrees of release. Pac. NW. Forest & Range Expt. Sta. Res. Note 168, 5 pp.

(During the first 3 years following controlled release in a 28-year-old, site V plantation, growth rate of dominants exceeded that of codominants, which in turn exceeded that of intermediates. The only indication of a progressive increase in diameter growth with increased release was found among the dominants, and differences were not statistically significant.)

Madison, Robert W.

Growth and survival of a Sitka spruce plantation in coastal Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 178, 6 pp., illus.

(Describes survival and height growth of 3-0 Sitka spruce seedlings on a coastal Oregon clearcut, and compares results on north and south slopes and burned and unburned sites.)

Three types of treatment kill brush, make roads safe, easy to maintain. The Timberman 60(13): 38-39, 68, illus.

(Reports results of tests designed to develop effective techniques for chemical control of roadside brush in coastal Oregon. The tests show that either foliage or basal treatment, or slashing followed by stump treatment, provide adequate control.)

Reukema, Donald L.

Missing annual rings in branches of young-growth Douglas-fir. Ecol. 40: 480-482, illus.

(On seven trees in the 35- to 70-year age range, a discrepancy of 9 or 10 rings was commonly noted between number of annual rings at the base of a live branch and in the tree stem at their point of intersection. These branches in the lower part of the crown all had plentiful and healthy appearing foliage. A significant inference is that lower branches contribute little or nothing to tree development.)

Some recent developments in the Wind River Douglas-fir plantation spacing tests. Pac. NW. Forest & Range Expt. Sta. Res. Note 167, 7 pp., illus.

(A comparison of 1957 results with those of previous measurements shows the value of planting at spacings as wide as 10x10 and 12x12 feet. The superiority of these wider spacings is shown by the earlier merchantability of trees, coupled with greater height growth.)

Silen, Roy R., and Woike, Leonard R.

The Wind River Arboretum, 1912-1956. Pac. NW. Forest & Range Expt. Sta. Res. Paper 33, 50 pp., illus.

(By 1956, 156 coniferous species had been tested at the Wind River Arboretum, and 42 of them had failed.™ Few introduced conifers had sustained growth rates of the native conifers within the same genus, and only a few individuals of introduced Larix or Picea species had sustained the average growth rate of Douglas-fir at the Arboretum. Broadleaf trees had not been tested since 1928 because several hundred test lots had been consistently poor in performance or had failed.)

Tarrant, Robert F.

1958 bibliography of Pacific Northwest forest soils publications. Pac. NW. Forest & Range Expt. Sta. Res. Note 169, 2 pp.

(Compilation of forest soils research publications pertaining to the region, issued during calendar year 1958.)

Trappe, James M.

Lodgepole pine clearcuts in northeastern Oregon. Jour. Forestry 57: 420-423, illus.

(Clearcuts in lodgepole pine were evaluated for soil disturbance, slash, regeneration, and ground vegetation. Based on these observations, preliminary recommendations for clear cutting lodgepole pine are given for this area.)

FOREST PROTECTION

Disease

Childs, T. W.

Elytroderma needle blight of ponderosa pine. U.S. Dept. Agr. Forest Pest Leaflet 42, 4 pp., illus.

(A brief description of the disease and its effects. Gives recommended marking practices for reduction of damage.)

Estimating decay in west-side Douglas-fir. Pac. NW. Forest & Range Expt. Sta., 8 pp., illus.

(Briefly describes the common heart rots and methods for estimating their extent in standing timber.)

Hunt, John

Phytophthora lateralis on Port-Orford-cedar. Pac. NW. Forest & Range Expt. Sta. Res. Note 172, 6 pp., illus.

(This disease has been known in the Pacific Northwest for more than 20 years, and in the natural range of its host since the early 1950's. Surveys indicate that it will eventually invade all except the most isolated parts of the range of Port-Orford-cedar.)

Fire

Cramer, Owen P.

Forest fire weather and computed fire occurrence in western Oregon and western Washington in 1959. Pac. NW. Forest & Range Expt. Sta. Res. Note 176, 11 pp.

(Fire season severity varied from below normal in western Washington to a record-setting high in southwestern Oregon. Fire occurrence that would be expected under the observed conditions was computed and compared with actual occurrence for the first time in this region.)

Relation of number and size of fires to fire-season weather indexes in western Washington and western Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 175, 11 pp., illus.

(Equations are presented for computing probable fire occurrence as a function of fire-season weather indexes. Number of man-caused fires and proportion of fires in smallest and largest area classes may be computed separately for national forests and for State and private lands within each State.)

Morris, William G.

Effect of weathering on accuracy of fuel-moisture-indicator sticks in the Pacific Northwest. Pac. NW. Forest & Range Expt. Sta. Res. Note 171, 6 pp., illus.

(Erosion of the surface and consequent loss of weight of fuel-moisture-indicator sticks exposed to weathering differs according to several climatic zones in Oregon and Washington. At one station in western Washington, wide variation in seasonal rainfall did not appreciably affect loss of weight, but nightly sheltering against dew greatly reduced loss. Within a given zone, loss of weight increases in proportion to duration of exposure.)

Insects

Buckhorn, W. J., and Orr, P. W.

Forest insect conditions in the Pacific Northwest during 1958. Pac. NW. Forest & Range Expt. Sta., 41 pp., illus.

(One of a series of annual reports summarizing the principal insect outbreaks in the forests of Oregon and Washington, as revealed by surveys in 1958.)

and Orr, P. W.

Forest insect conditions in the Pacific Northwest during 1959. Pac. NW. Forest & Range Expt. Sta., 37 pp., illus.

(A summary of the principal insect outbreaks in the forests of Oregon and Washington in 1959.)

Carolin, V. M., and Coulter, W. K.

The occurrence of insect parasites of Choristoneura fumiferana (Clem.) in Oregon. Jour. Econ. Ent. 52: 550-555.

(A summary of recoveries of primary parasites attacking the spruce budworm in Oregon, with estimates of the abundance and distribution of major species during the period 1948-56.)

Furniss, Robert L.

Answers to some criticisms of aerial spraying in forest management. Jour. Forestry 57: 260-262.

(Answers various questions that have been raised by critics of aerial spraying, especially with regard to the supposed "upsetting of the balance of nature.")

Use of spraying as a tool in forest management. West. Forestry and Conserv. Assoc. Proc. 1958: 30-32.

(Gives particular attention to aerial spraying of forest lands to control insect infestations. The six most common criticisms of forest spraying are discussed.)

Johnson, N. E., Orr, P. W., and Wright, K. H.

Beetle hazard in windthrown Douglas-fir. Weyerhaeuser Co. Forestry Res. Notes Res. Paper 20. 3 pp.

(Discusses potential of various types of windthrow as breeding ground for the Douglas-fir beetle.)

FOREST PRODUCTS UTILIZATION

Knauss, A. C., and Clarke, E. H.

Seasoning and surfacing degrade in kiln-drying Douglas-fir in western Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 173, 13 pp.

(Presents results of a study to determine loss in volume and grade of Douglas-fir lumber when kiln-dried and surfaced in accordance with commercial practice. Indicates opportunities for profiting from improved practices to capture more of the potential lumber value in the log.)

Wright, Ernest, Knauss, A. C., and Lindgren, R. M.

Sprinkling to prevent decay in decked western hemlock logs. Pac. NW. Forest & Range Expt. Sta. Res. Note 177, 10 pp., illus.

(Shows effectiveness of sprinkling decked hemlock logs with water to retard development of decay and consequent loss in pulp yield.)

RANGE MANAGEMENT

Strickler, Gerald S.

Use of the densiometer to estimate density of forest canopy on permanent sample plots. Pac. NW. Forest & Range Expt. Sta. Res. Note 180, 5 pp., illus.

(Describes methods and techniques used in adapting a spherical densiometer for estimation of canopy density in range and forest inventory work.)

WATERSHED MANAGEMENT

Bethlahmy, Nedavia

Forests and water yield. (Closure.) Amer. Soc. Civ. Engin. Proc. 85(SA4-2098): 107.

(Refutes an engineer's argument that forests do not influence the forest environment or the disposition of precipitation.)

Reducing evaporation from small reservoirs. Northwest Sci. 33: 135-138.

(Hexadecanol was shown to reduce evaporation losses from small water storage areas by 42 percent.)

The use of electrical resistivity apparatus in soil investigations. Amer. Soc. Agr. Engin. Trans. 2(1): 68-70, illus.

(Electrical resistivity methods can be used in soil studies if curve-matching techniques are employed.)

Rothacher, Jack

How much debris down the drainage? The Timberman 60(6): 75-76, illus.

(The problem of logging debris in streams is discussed. Sample calculations are included to illustrate maximum volume and depth of water in small streams on the west slopes of the Cascades.)

GENERAL

Adams, Thomas C.

Review of "Economics of American Forestry," by Albert C. Worrell. Amer. Econ. Rev. 49: 792-793.

(Reviews a college textbook that presents the economic principles underlying American forestry problems.)

Berntsen, Carl M., and Rothacher, Jack S.

A guide to the H. J. Andrews Experimental Forest. Pac. NW. Forest & Range Expt. Sta., 21 pp., illus.

(An illustrated description of forest and watershed management research on a 15,000-acre watershed in the old-growth Douglas-fir timber type.)

Costello, David F.

Review of "The Federal Lands: Their Use and Management," by Marion Clawson and Burnell Held. Jour. Wildlife Managt. 23: 378-379.

(Reviews a book that summarizes the economics, use patterns, and policy decisions relating to the federally owned lands of the United States.)

Gedney, Donald R., Martin, Dorothy E., and Johnson, Floyd A.

Specifications for calculating several equations of relationship between two variables on a type 650 electronic computer. Pac. NW. Forest & Range Expt. Sta., 15 pp., illus.

(Input and output specifications are described for an electronic data processing program that develops seven different equations of relationship between a dependent variable and powers of an independent variable.)

Hayes, G. L.

Forest and forest-land problems of southwestern Oregon. Pac. NW. Forest & Range Expt. Sta., 54 pp., illus.

(Forest and forest-land resources and social and economic development are summarized as background for a discussion of forest-management and watershed problems of southwestern Oregon. Priorities of research needs are listed.)

Pacific Northwest Forest and Range Experiment Station

1958 Annual Report, 94 pp., illus.

(Summary of Station research accomplishments during calendar year 1958 and plans for 1959.)

Pacific Northwest Forest and Range Experiment Station

Research for multiple-use forestry. 39 pp., illus.

(Describes the many problems involved in realizing maximum returns from forest resources in the Pacific Northwest through multiple-use management, and explains the role of research in solving these problems.)

Skinner, Edgel C.

Cubic volume tables for red alder and Sitka spruce. Pac. NW. Forest & Range Expt. Sta. Res. Note 170, 4 pp.

(These three new cubic-foot volume tables--two for red alder and one for Sitka spruce--cover omissions and discrepancies in a previously published set of volume tables recommended for use on permanent sample plots.)

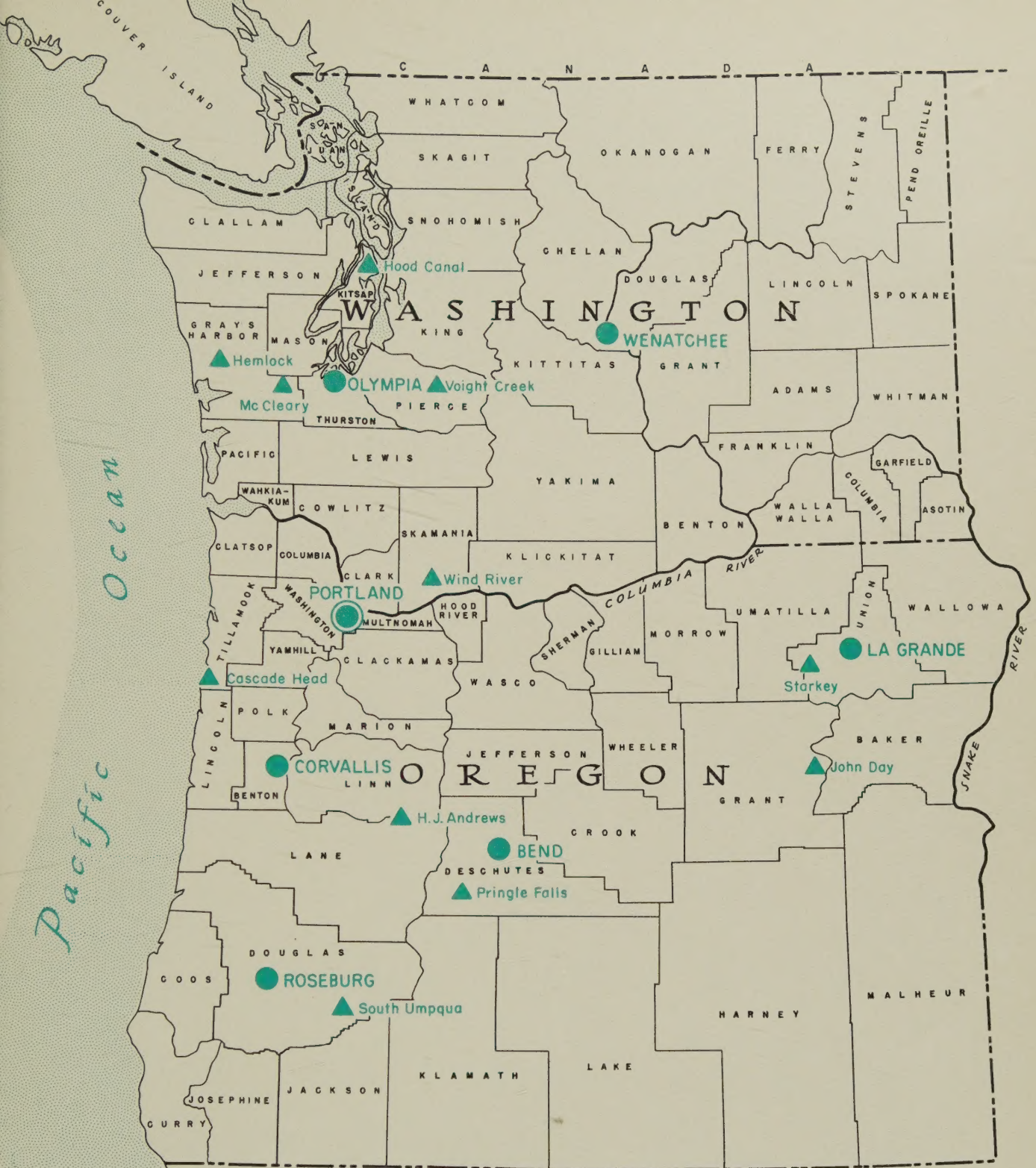
ADDENDUM

The following item was omitted from the bibliography of the Station's 1958 Annual Report:

Matson, E. E.

The place of fiberboard and particle board industry in a developing forest economy in the U.S. In Fibreboard and particle board, vol. V. United Nations Food and Agr. Organ., 10 pp., illus.

(Emphasizes the need for continued expansion of the board industry and for development of other manufacturing techniques to utilize small-sized thinnings and wood residue produced at primary manufacturing plants.)



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